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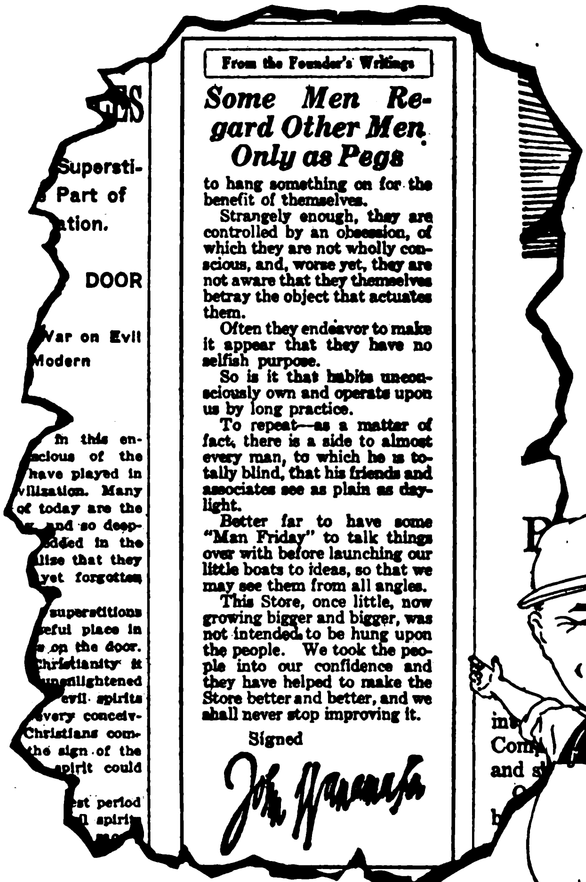
The Man Who Delivers the Goods

and something about "habits" that applies to you and to me and everybody else

HERE is a snack of wisdom from a plain man who established his name and an institution that is known in its line the world around. As we pause to note the incoming of a new year on our calendars and in the dates we write, we can well afford to roll over in our minds the remarks in this clipping from a recent advertisement in the *New York Times*.

"Habits," said John Wanamaker, "unconsciously own and operate upon us by long practice." A larger hunk of truth could hardly be expressed in ten other plain and understandable words. Year by year we are growing older and should be growing wiser and more thoughtful about the future and the present and be able to judge as to how well we are taking advantage of our opportunities and using our accumulated knowledge and experience. But that thing habit to which is attached indifference, procrastination, and laziness, both mentally and physically, is the log in the way on that path along which we feel we should march proudly to success with our share of glory attached to accomplishment. It is easy to pass the buck to the other fellow, and to circumstances, and miscellaneous other hindrances, but when we stop and think to ourselves, its really that thing "habit" that's holding us back.

Sure! I've got habits and bad ones at that, but I know it and have to fight 'em all the time—that's the reason this comment by John Wanamaker has struck home in me so deeply and caused me to pass it on to prick you a little. Personally, I have passed the stage where I get a thrill out of the happenings and experiences of a younger day and I like to sit and dream about the future and the things that are to be in the world that I know most about. This is the world of machinery and the



From the Founder's Writings

Some Men Regard Other Men Only as Pegs

to hang something on for the benefit of themselves.

Strangely enough, they are controlled by an obsession, of which they are not wholly conscious, and, worse yet, they are not aware that they themselves betray the object that actuates them.

Often they endeavor to make it appear that they have no selfish purpose.

So is it that habits unconsciously own and operate upon us by long practice.

To repeat—as a matter of fact, there is a side to almost every man, to which he is totally blind, that his friends and associates see as plain as daylight.

Better far to have some "Man Friday" to talk things over with before launching our little boats to ideas, so that we may see them from all angles.

This Store, once little, now growing bigger and bigger, was not intended to be hung upon the people. We took the people into our confidence and they have helped to make the Store better and better, and we shall never stop improving it.

Signed

John Wanamaker

problems of men who start it up, close it down and make the necessary repairs and changes one day after another as a part of the day's job. For this they get a day's wage. But as years roll on they get something far more valuable in an accumulated fund of knowledge and experiences that cannot be purchased, lost or stolen. As we march on in point of time, this fund of knowledge becomes a bank account on which we can earn a small or an adequate return according to whether we follow the habits of the spendthrift or the habits of the investor. And there you have that thing "habits" coming up.

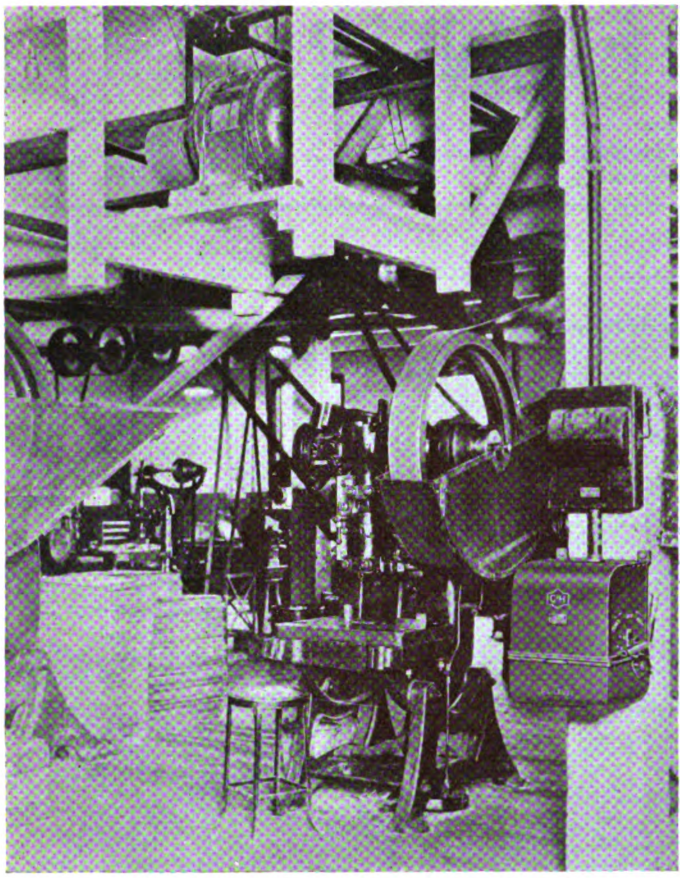
In this clipping he said another good thing: "Better far to have some Man Friday to talk things over with before launching our little boats to ideas." Now, at the beginning of this new year 1926, is a good time to do some new thinking and new planning along this line. Perhaps you have had some good ideas but time has shown that your judgment cannot always be trusted. If you know this is true admit it and take your boss or some other successful associate into your confidence and have a heart-to-heart talk. Go over the things that have not turned out as well as they might, as well as those that have been just about right. Perhaps you have overlooked something he will see and you will discover an easy and quick way out of the woods and into the open spaces.

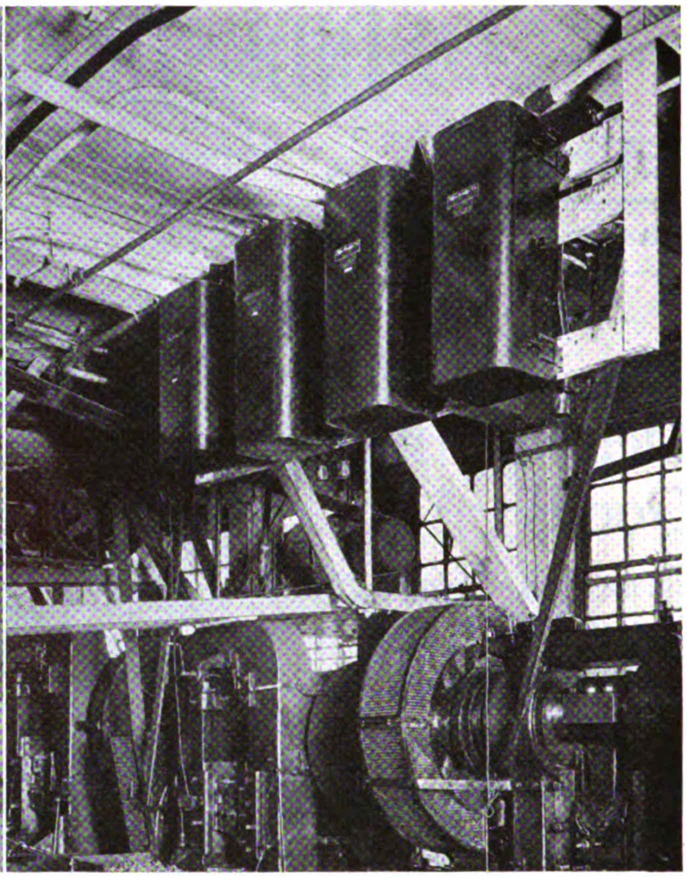
An unknown author has put into the following verse a thought that we all know and that is the key to every man's success—it runs like this:

There's a man in this world who is never turned down,
Wherever he chances to stay;
He gets the glad hand wherever he goes,
Or wherever the farmer's make hay.
He's greeted with pleasure on deserts of sand,
And deep in the isles of the woods;
Wherever he goes there's a welcoming hand,
He's the man who delivers the goods.

The year 1926 is going to discover many such men among those who read this, but remember what John Wanamaker said about Habits and that Man Friday.

Practical Pete





Here are applications of compensators and primary-resistance starters to similar service. At the left is a Cutler-Hammer manually-operated compensator controlling the motor driving a punch press. On the right is a group of Allen-Bradley automatic, primary-resistance starters which are used to start the motors driving punch presses. Inasmuch as the latter starters are push button controlled they can be located wherever conditions permit—in this case they are mounted on the ceiling.

Operating characteristics of

Compensators and Primary Resistance Starters

as used for starting squirrel-cage induction motors, including comments on the application of and the results obtained from each type of starter

Symposium Conducted by

ARTHUR J. WHITCOMB

Associate Editor, Industrial Engineer

WHEN starting a squirrel-cage induction motor by applying line voltage directly to its terminals, a starting current of six to eight times full-load current may be drawn from the line. This starting current may not be objectionable on large power systems, particularly in the case of motors of 7½-hp. capacity and smaller, but inasmuch as excessive starting current results in objectionable line disturbances, practically all public utilities have definite regulations regarding the size of squirrel-cage motor that can be put directly across the line.

The starting current of a squirrel-cage motor depends upon the voltage impressed on the primary or stator terminals of the motor and is independent of the torque against which the motor is to start. The peak current at starting is of short duration, for the current falls quickly to the normal running value as the motor accelerates. The duration of the starting period depends upon the character of the load to be started. Inasmuch as the initial rush of current is controlled by the voltage impressed on the motor, this voltage may well be reduced to a value that is little more than sufficient to start the load under all normal conditions.

Reduced potential for starting is commonly obtained either by the use of auto-transformers or by using resistance. The older and probably more common practice involves the use of auto-transformers in compensators or auto-starters. A compensator consists usually of two and sometimes three auto-transformers arranged with different voltage taps so as to supply the desired voltage.

With the primary-resistance method of starting, reduction of the voltage impressed on the motor is secured by the insertion of resistance in series with the primary or stator windings of the motor. The amount of resistance may be adjusted to secure the desired starting voltage and torque. As the motor attains speed, the resistance is cut out in one or more steps.

Primary-resistance starting differs distinctly from the compensator method in that the latter causes a reduced voltage of constant value to be impressed on the motor, whereas

with the primary-resistor method, the voltage impressed on the motor varies according to the current taken by the motor. The initial inrush of current causes a large drop in voltage over the resistors; hence the initial voltage impressed on the motor is low and gradually increases as the motor speeds up and the motor current decreases.

Compensators reached a higher point of development earlier than the primary-resistor starters and hence the use of compensators is more general. However, rapid progress has been made in recent years in the development of primary - resistance starters. At the present time there is uncertainty in the minds of many users of electrical equipment regarding the application and use of each type of starter. Many operators favor compensators, while others are just as decided in their convictions that the primary-resistance method gives better results. To help clear up this question and to aid our readers in deciding which type of equipment is better suited to the conditions to be met in their own plants, the Editors of INDUSTRIAL ENGINEER asked the leading manufacturers of compensators and primary-resistance starters to discuss the characteristics and application of these two types of equipment.

Points that should be considered in the selection and application of these two types of starters are: line disturbance, line current, power factor, power taken from line, torque, duration of starting period, losses and efficiency, smoothness of operation, ease of control, reliability, ease of repair and maintenance, size and application, and cost. These points are fully covered in the discussions which follow.

* * * *

T. E. Barnum, Chief Engineer, The Cutler-Hammer Manufacturing Company, Milwaukee, Wis.—In the selection of a motor for a given application, motor characteristics are usually considered first. In the following discussion, it is assumed that the standard squirrel-cage motor has been selected as meeting the general requirements and that the only question is, whether a primary resistor or an auto-transformer will be used to reduce the voltage at the motor terminals at starting. To answer this question, several factors must be considered, which will be discussed in the following:

Line Disturbance.—The severity of line disturbance depends on the conditions of the particular installation, such as load on the circuit, capacity of the transformer bank, size of the conductors, and similar factors. Any statement is, of course, purely comparative. For example, assume that the motor can be started with 65 per cent of line voltage applied to the motor terminals. If, because of the general conditions, the drop in voltage on the line is 4.4 per cent when an auto-transformer is used, then the drop would be 5.5 per cent if a primary resistor were used. Similarly, where with the auto-transformer the voltage drop might be 1.7 per cent, with primary resistors the corresponding drop would be 2.2 per cent. This small difference is due to the better power factor of the resistor method.

Line Current.—The current taken from the line at the moment of starting is materially less with the auto-transformer than with the primary resistor, but not quite in proportion to the ratio of transformation, due to the magnetizing current of the transformer. In order to give some comparative figures, certain tests were made on a 20-hp., 440-volt, three-phase, 60-cycle, 1,720-r.p.m., squirrel-cage motor. When adjusted to give about 65 per cent of line voltage at the motor terminals with the rotor blocked, the line current with the auto-transformer was 260 per cent of the rated motor current, while with a block of resistance in each of the three phases of the primary circuit, the line current was 340 per cent of the rated motor current. When adjusted to give about 80 per cent of the line voltage at the motor terminals, the line currents were 390 per cent with the auto-transformer and 450 per cent with the primary resistor. These figures may also be taken as representing the performance of the average motor of 10 to 30 hp.

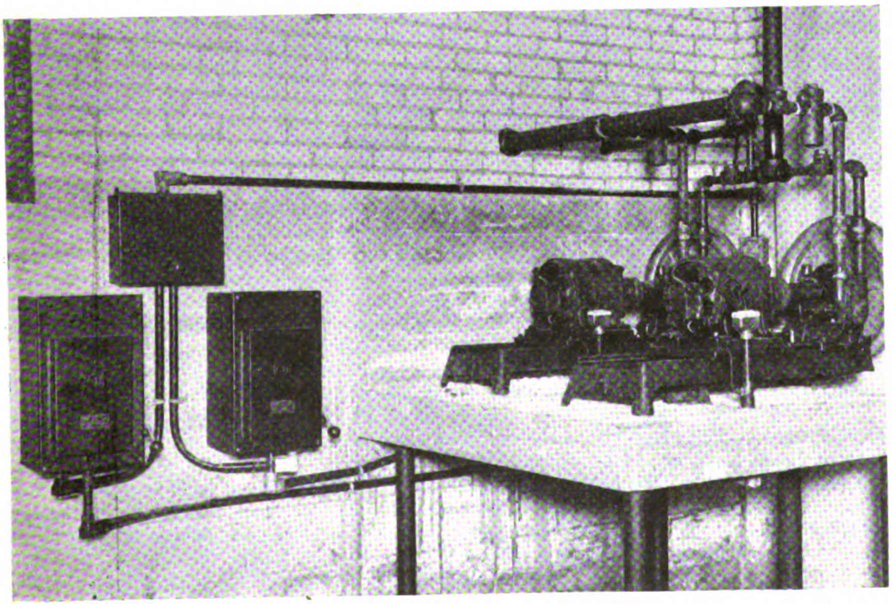
Power Factor.—The power factor of the line at the moment of starting is materially higher with the primary resistor than with the auto-transformer. When adjusted to give 65 per cent of line voltage at the motor terminals for starting, the power factor with the primary resistor runs from 80 to 85 per cent, depending upon the motor size; whereas with an auto-transformer, under the same conditions, the power factor of the line runs from 50 to 60 per cent, varying again with the size and characteristics of the motor, motor speed, and the like.

Power From the Line.—Power taken from the line at the moment of starting, measured in kilowatts, is materially less with the auto-transformer than with the primary resistor, partly because of the reduced line current but largely because of the reduced power factor. When line disturbance is not taken into account and with 65 per cent voltage applied to the motor, the power taken from the line at the moment of starting with an auto-transformer is about 50 per cent of that which would be taken with a primary resistor. Similarly, with 80 per cent voltage applied to the motor, the power taken from the line with an auto-transformer is about 60 per cent of that taken with a primary resistor. However, if the time to accelerate to full speed is considered, the difference in energy taken during this period is not so large, because the time is shorter when a resistor is used than with an auto-transformer.

Torque.—The torque developed by the motor in question is independent of the method used to reduce the voltage at its terminals and, for a given motor, depends only on the actual voltage impressed on it. For modern applications of such a motor, a fairly high torque is required of the motor due to the fact that the load to be started is fairly heavy. Starting conditions for such a squirrel-cage motor are very rarely what may be called light, and quite generally such a motor is called upon to develop very nearly its full load torque at the moment of starting. For a motor of 1,800 r.p.m. synchronous speed, about 80 per cent voltage is necessary at the motor terminals, to

Manually-operated primary-resistance starters are used on this installation.

They control the motors driving the fans and pumps of an oil burning equipment installation. Cutler-Hammer starters are used here.



develop this torque. As stated above, the line current with the auto-transformer is somewhat less than that with the primary-resistor method. Conversely, of course, for a given line current, the torque that may be developed at the motor is materially higher when an auto-transformer is used, because a higher voltage can be applied at the motor terminals.

Smoothness of Operation.—Considering the acceleration of the motor, after it has once started to rotate, there are many advantages with the primary resistor method. As the motor accelerates, the line current decreases, which automatically increases the voltage at the motor terminals. Thus the torque at the motor builds up much faster when the primary-resistor method is used, and the motor comes up to speed in a shorter time. Again, there is no loss of torque while the motor is being accelerated to full speed, since the resistor may be cut out of circuit in one or more steps without opening the circuit, whereas with the usual auto-transformer starter, the circuit is opened in passing from the starting to the running position, giving a momentary high current peak and, unless the change is made quickly, will result in some decrease in speed of the squirrel-cage motor.

Size and Application.—In general, when considering the application of a standard squirrel-cage motor, the only question involved is the permissible starting current that may be taken from the line. The National Electric Light Association has developed certain rules for permissible starting currents, which limit the use of this type of motor on central station supply lines to 30 hp. and below. It is probable that up to and including 20 hp., the primary-resistor method can be used under almost any condition. For 20 hp. and larger, judgment must be used, depending upon the particular motor application, power supply, etc. It is, of course, possible to build primary-resistor starters of any size for use in starting low-voltage, squirrel-cage, induction motors.

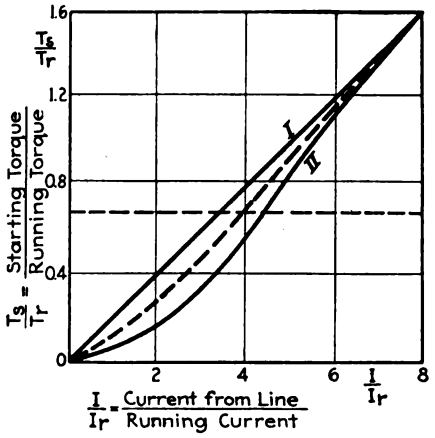
Cost.—For moderate sizes of motors, the size and cost of the primary-resistor starter are less than for the corresponding auto-transformer starter. This difference will vary somewhat with the voltage reduction supplied, since considerably more resistance material is required to reduce the motor voltage to 65 per cent than is necessary to reduce it to 80 per cent.

Ease of Control.—As regards ease of control, care is necessary with both types. Perhaps a little more skill is necessary with the auto-transformer type because of the requirement that the transition from the starting to the running step must be made very quickly.

Then, assuming that other conditions are equal, there is no advantage either way on the score of safety or reliability. Maintenance is, of course, a matter of the design of the starter in question. Assuming that both methods use the air-break type of contact, there should be no difference in maintenance.

G. O. Wilms, Chief Engineer, Allen-Bradley Company, Milwaukee, Wis.—There are two types of primary-resistance starters. In one type the resistance is cut out in one step; sometimes, however, two or more steps of resistance are used. In the other type, the resistance is gradually cut out steplessly by compressing the resistor. This latter type is known as the compression resistance starter and is the type made by my company.

Both of these types of starters provide two distinct advantages over the compensator—one is that the voltage on the motor will gradually increase as the starting current decreases with the increasing speed of the motor, and the other is that the motor is not disconnected from the line when connected



Line currents required by compensators and primary-resistance starters for various values of starting torque.

Curve *I* is the current drawn from the line by the compensator while Curve *II* represents the current taken by a primary-resistance starter. The vertical scale is expressed as the ratio of the starting torque required to the running torque. The horizontal scale is given in the ratio of the current taken from the line to the running current. It will be noticed from these curves that for a given starting torque, a larger starting current is required by the primary-resistance method, as shown in curve *II*. However, the higher the starting torque required, the closer will the two curves coincide, thereby diminishing this advantage.

to full voltage, thereby reducing the second current inrush to a minimum. However, let us consider in detail the characteristics of both compensators and resistance starters.

Line Disturbance.—The question as to the line disturbance caused by a primary resistor starter will best be answered by the oscillograph curve shown on page 6. This oscillogram shows the starting characteristic of a 20/25-hp. motor started in 1½ sec., with manually-operated, compression resistance starter. Even under these conditions there are no sudden peaks.

Line Current.—The resistance-type starter will take proportionally more current from the line depending on the voltage required to start the motor.

Power Factor.—Since the transformers used in the average compensator are not very efficient, the exciting current is rather high, thereby giving additional reduction in power factor.

Losses.—The losses during starting will be higher with the resistance-type starter since actual power is dissipated in the resistors. These losses will get proportionally smaller as higher voltages are required to start the motor. Losses during starting will only become of importance when motors are started frequently, but will be more than offset by the reduced line disturbances and shock to the driven machine.

Efficiency.—The primary-resistance starter will take more current from the line than the compensator, and the difference is greater the lower the tap used on the compensator. If, however, the compensator is connected to the 75 per cent or a higher voltage tap this difference is not very much. This condition has been shown in the diagram on this page. An investigation of large compensator installations made some years ago would indicate that the majority are connected to the 75 per cent or higher taps in order to be able to start the motor under all load conditions. If, for instance, a motor will start at 70 per cent voltage on an average, but the load is such that a higher voltage is required at times, the compensator would have to be connected to a higher tap. With the primary-resistance starter of the graphite-compression type, it would only mean additional pressure applied to the compression resistors, which can be applied by the operator, to get the motor started on the heavier loads. In such cases the power taken from the line as an average may be even higher with the compensator than with the resistance-type starter.

Cost.—Up to 100 hp. the cost of the compression-resistance starter is in line with average compensator prices. For higher horsepower the graphite-compression type starter becomes more expensive.

Torque Available from Motor.—Since the current is under the control of the operator, the torque will also be. Inasmuch as the voltage automatically increases across the motor terminals as the starting current reduces, a higher torque is obtained even if no additional resistance is cut out after the motor has once started. This is the reason that a single-step, primary-resistance starter will give good starting conditions.

Smoothness or Freedom from Shock in Equipment Driven.—Due to the small current inrush and the possibility of building up the starting current to just the value at which the motor starts, the driven machine can be started very gradually without any shock. This will prevent belt-slipping and reduce the strain on gear-driven machinery.

Space Requirements of Each Type.—Up to 100 hp. the Allen-Bradley starter is built in the wall type, and for above 100 hp. it is made in the floor type. The larger starters have a tendency to get bulkier than the compensators, which is primarily due to the air-break switches used which require more room. But when it comes to motor sizes above 50 hp., the size of the

starting equipment is not of such vital importance. For smaller starters which are frequently grouped, the average space taken by compensators can very well be met.

Ease of Control.—Since the hand levers in the case of manually-operated starters are thrown in one direction only, mistakes in starting are practically eliminated. Operating handles can be furnished with a delay in action so that the operator cannot accelerate the motor too rapidly.

Reliability.—The statement can very well be made that primary-resistance starters are just as reliable as the compensator. Since the primary-resistance starters all use air-break switches, which are easier to inspect than the oil-immersed type switches used with the average compensator, their reliability is rather higher than lower.

Ease of Repair and Maintenance.—Since no oil switches are used, inspection is easy. The starters are mounted as a unit inside of a cabinet from which they can easily be taken out for repairs. Resistance units can be withdrawn by removing two connections.

Sizes in Which Each Type Is Made.—Graphite-compression type starters for squirrel-cage motors, both hand and automatic types, are made up to 400 hp. for all voltages. The newest type of hand starters manufactured by the Allen-Bradley Company are all of the semi-automatic type and are made in sizes up to 100 hp. The starting switch is inside the resistance unit for this size. For larger sizes, the starting contacts are magnetically-operated switches. Since the first current inrush is only 30 to 50 per cent of normal full-load current, very little flashing is experienced on the starting contacts.

Safety to Power Service and Workmen.—All starters are fully enclosed, providing safety to workmen. Starter covers can be locked closed. Stopping on all hand starters is accomplished by a stop button on the outside of the cabinet. Due to the small current inrush very little line disturbances are experienced, thereby reducing main line fuse blowing to a minimum.

Character of Applications to Which Each Type of Starter Is Particularly Adapted. — Primary-resistance type starters can be used everywhere that compensators are used. Where machinery has to be started carefully or where line disturbances have to be kept to a minimum they are superior to compensators.

Are There Any Applications to Which You Do Not Recommend One or the Other of These Two Types of Starters?—The only place where an investigation is necessary before a primary-resistance type starter can be used is where large, squirrel-cage motors have to be started from a limited power supply. In such cases, the compensator, if the motor can be started on a low tap, is better adapted, since less power is required to start the motor. There are, however, cases where the primary-resistance type starter works out better, and these are where the power plant has sufficient momentary overload capacity if the governor is given time to act, which can be accomplished by building up the load gradually with a primary-resistance type starter.

We are naturally very enthusiastic about the graphite-compression type starter and are thoroughly convinced that this method of starting is superior. Power companies in large centers of distribution like New York, Chicago, Detroit, St. Louis, are beginning to realize that the amount of power used during starting is not so objectionable as long as this power is drawn slowly enough.

* * * *

W. C. Yates, Manager, Industrial Controller Sales, General Electric Company, Schenectady, N. Y.—The size of squirrel-cage induction motors that may be started without any current limiting means is determined by two considerations: First, the regulations of the power supply company and, second, the strength of the motor windings in view of the strain imposed.

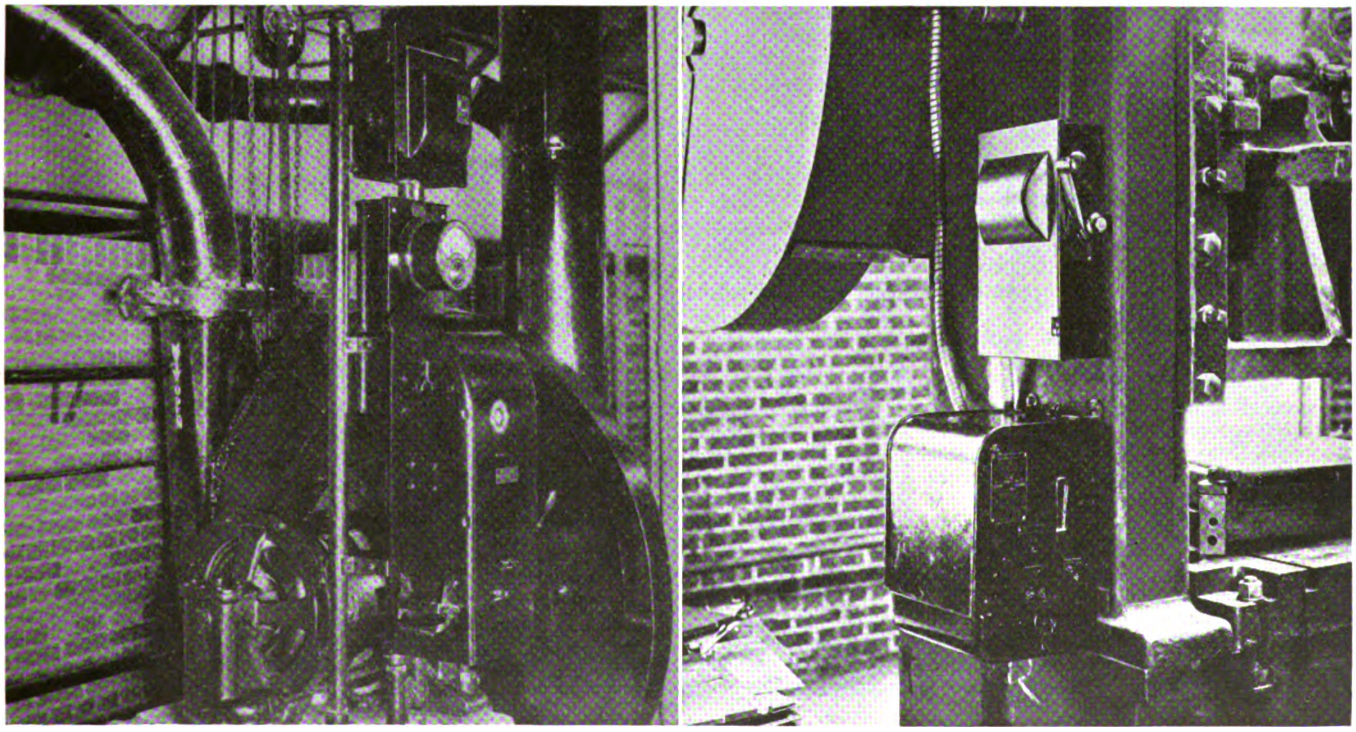
Most power companies put out printed regulations which make more or less definite statements as to the size of squirrel-cage motors that may be thrown on the line without a starter. Frequently, however, when special cases are taken up with them, rulings are made which permit throwing larger squirrel-cage motors across the line than are indicated by the printed regulations.

Squirrel-cage motors may well be thrown directly on the line to start whenever it is permissible. Such is now the generally accepted practice for starting motors up to 7½ hp. and, as far as the better grades of motors now on the market are concerned, could safely be done with motors up to 20 hp.

When the starting current must be limited, there are two common methods of accomplishing this: by a compensator (or auto-transformer) or by a resistor in the primary circuit. The

Two applications of manually-operated compensators to squirrel-cage motors.

At the left is a General Electric compensator controlling a motor rated at 20/25 hp., 3,600 r.p.m., 220 volts. Notice the very convenient arrangement of compensator, ammeter, and safety switch, all on the same pipe frame mounting. At the right is a manually-operated compensator controlling the motor driving a shear. The starting duty on an application of this kind is severe, inasmuch as a heavy flywheel must be accelerated. A Westinghouse auto-starter, or compensator, and safety switch are used in this installation. Notice the use of flexible conduit for machine wiring.



compensator has long been the standard for general application, if numbers mean anything, but of late years the advocates of the primary-resistor starter have made themselves heard sufficiently to raise several questions which many industrial plant operators would like to have answered.

The resistor starter in general practice may be considered as a half-way step between the auto-transformer or compensator starter and the full voltage or across-the-line type starter. Generally, the resistor starter provides approximately 80 per cent of line voltage, and the compensator starter about 60 per cent of line voltage. We then have these three lines:

(1) Full voltage starters, generally applicable to 7½-hp. motors and less.

(2) Resistor starters giving 80 per cent line voltage, applicable to motors from 10 to 20 hp.

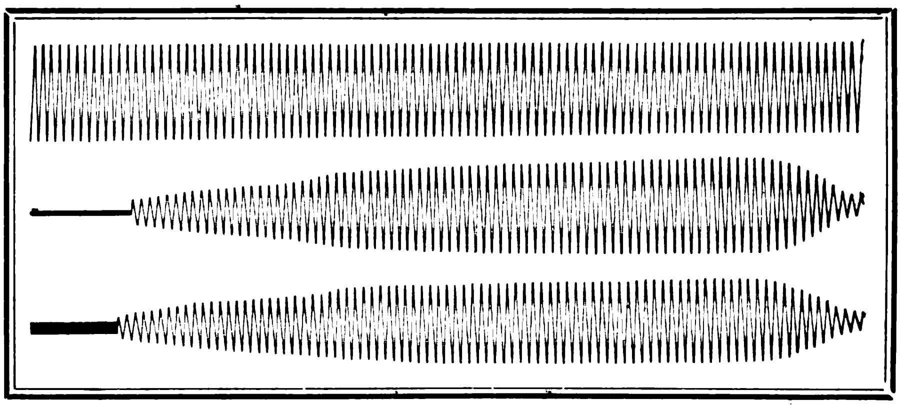
(3) Transformer starters giving usually 60 per cent of line voltage, but readily adjustable to give higher or lower voltages, and applicable to larger motors.

For small sizes of motors (up to about 20 hp.) on low voltage, the primary-resistor starter has some advantages over the compensator in regard to size, weight, and cost. It provides a better accelerating characteristic, in that as the motor accelerates and as the line current decreases, the voltage on the motor and consequently its torque increase. This is at the expense of a larger initial current inrush drawn from the line than a compensator requires, which means that the starting current limitations of central stations and the starting torque required of the motor must be considered before applying a resistor starter. With the same *line* starting current a compensator will give 60 to 80 per cent greater starting torque.

With the resistor starter, the line circuit is not broken and made again, as is the case upon the throw-over from starting to running on a compensator. The circuit is maintained, and the second accelerating peak, which occurs when the resistance is shorted out, is therefore less than the second peak on starting with a compensator. However, this does not matter greatly, for with a compensator the second current peak which may, under certain conditions, be higher than the initial inrush, lasts for but a few cycles and has no noticeable effect upon the line voltage. An oscillogram shows practically no voltage drop.

This second current peak does have an effect upon the motor itself but it is not objectionable until we reach sizes of several hundred horse power when use of the Korndorfer method with its transition feature becomes advisable. This method, however, does not eliminate the starting compensator.

Those who advocate the stepless resistor starter claim that it offsets many of the arguments made against the resistor starter. It is true that a gradual increase to that current that will start a motor is of advantage in minimizing the effect on the line voltage, but apart from that, this type is open to the criticisms that can be laid against any resistor starter. Then, too, the gradual increase is more of a theory than an actuality in service with a manual starter; and it cannot be taken advantage of in a magnetic starter.



Oscillograph record of the line voltage and motor current during starting with primary resistors.

This oscillogram was taken on a 25-hp., three-phase, 220-volt, squirrel-cage, induction motor while being started with an Allen-Bradley primary-resistance starter. The top curve shows the actual alternations of the line voltage during the starting period. The drop in line voltage during this starting period is 4.8 per cent. The two bottom curves represent the current flowing in two of the legs of the motor. As may be seen, the current starts at a small value and gradually builds up to the point where the motor starts accelerating. The current then gradually decreases. The ratio of the starting current to full-load running current in this case is 2.8 to 1. The duration of the starting period was 1.5 sec.

A compensator is a voltage changing device, and a resistor is an energy dissipating device. For motors above 20 hp. where long and frequently repeated starts must be made, a resistor to have the same capacity as a compensator would be larger and more expensive.

The primary-resistor starter has a place in the application field for the smaller motors and may be used with larger motors driving centrifugal pumps, fans or other light starting loads. A properly-designed compensator has no limitations as the right starter for general applications and can, therefore, be so recommended. In larger sizes, low voltage, and in all high-voltage starters, the resistor method is at a disadvantage as to size, weight and cost for equal capacity.

* * * *

J. S. Rowan, President, The Rowan Controller Company, Baltimore, Md.—In comparing primary-resistance starters with compensators they can be compared from two general standpoints. The first to consider, and which is probably the oldest comparison, is the question of line disturbance.

When considering line disturbance it is first absolutely necessary to eliminate the hand starter of either type because with the hand starter the line disturbance is going to depend upon how the operator starts the motor.

A number of power companies have made a lot of current rulings and at the same time are selling their customers hand-operated equipment which surely seems, to the writer, to be ridiculous. The only way line disturbance can be controlled is by means of an automatic starter where the time of acceleration is automatically taken care of and thereby taken out of the hands of the operator.

In comparing the question of line disturbance, tests made by the writer have shown that on light starting jobs the automatic compensator gives less line disturbance than the primary-resistance type and this is the only point at which the compensator shows up more favorably than the primary-resistance type. However, this does not apply in certain classes of machines such as fans, blowers and other centrifugal devices.

On the very heavy starting jobs, where high starting voltages are required, the line disturbance is more favorable to the primary-resistance starter because the initial peak is approximately the same, whereas the second peak of current is far less in the case of the primary-resistance starter than with the compensator.

In regard to power factor it is self-evident that the primary-resistance starter is very superior and in plants where there is a heavy penalty for power factor, primary resistance is often justified from this standpoint alone.

To my mind, however, the question of line disturbance is only part of the story and in many cases is a very small part. The big factor in a great many cases is, How do the two types affect the cost of production? When compared from this standpoint I feel that there is very little room for comparison.

The question of throwing the operating lever from the starting to the running position, of the two types, is inherently simpler with the resistance type and, other things being equal, simplicity is bound to mean greater reliability.

Of course, fair-minded people will recognize that either type is subject to failure and burnouts sooner or later, especially on hard service jobs. There is this difference, however, between the two types. The primary-resistance type can be repaired much easier and at far less cost, consequently eliminating a considerable delay in the shutting down of the machine which

very often runs into big money and greatly affects production costs of plants. In fact, any plant that employs their own electricial men rarely has any need for a costly delay with the primary-resistance type, as the resistance contactor can temporarily be blocked in until the time can be spared for the proper repairs. I believe that this little feature is the big deciding one as to the relative advantages of the two types.

Primary-resistance starters are manufactured by The Rowan Controller Company in standard sizes up to 300 hp. and will be built on special order in larger capacities.

* * * *

H. D. James, Manager, Control Engineering Dept., Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.—There is a general tendency towards the use of full-voltage starting for squirrel-cage, induction motors. This does not require either a resistor or auto-transformer starter. The rules of the various power companies limit the inrush current in starting motors where the customer is connected to a low-voltage distribution network or where several customers are supplied from transformers of limited size.

However, large industrial establishments are not limited by these rules. Some of these large users have been experimenting with full-voltage starters for motors as large as 100 hp., where the design of the motor was checked to see that the windings would stand the strain of the initial current inrush.

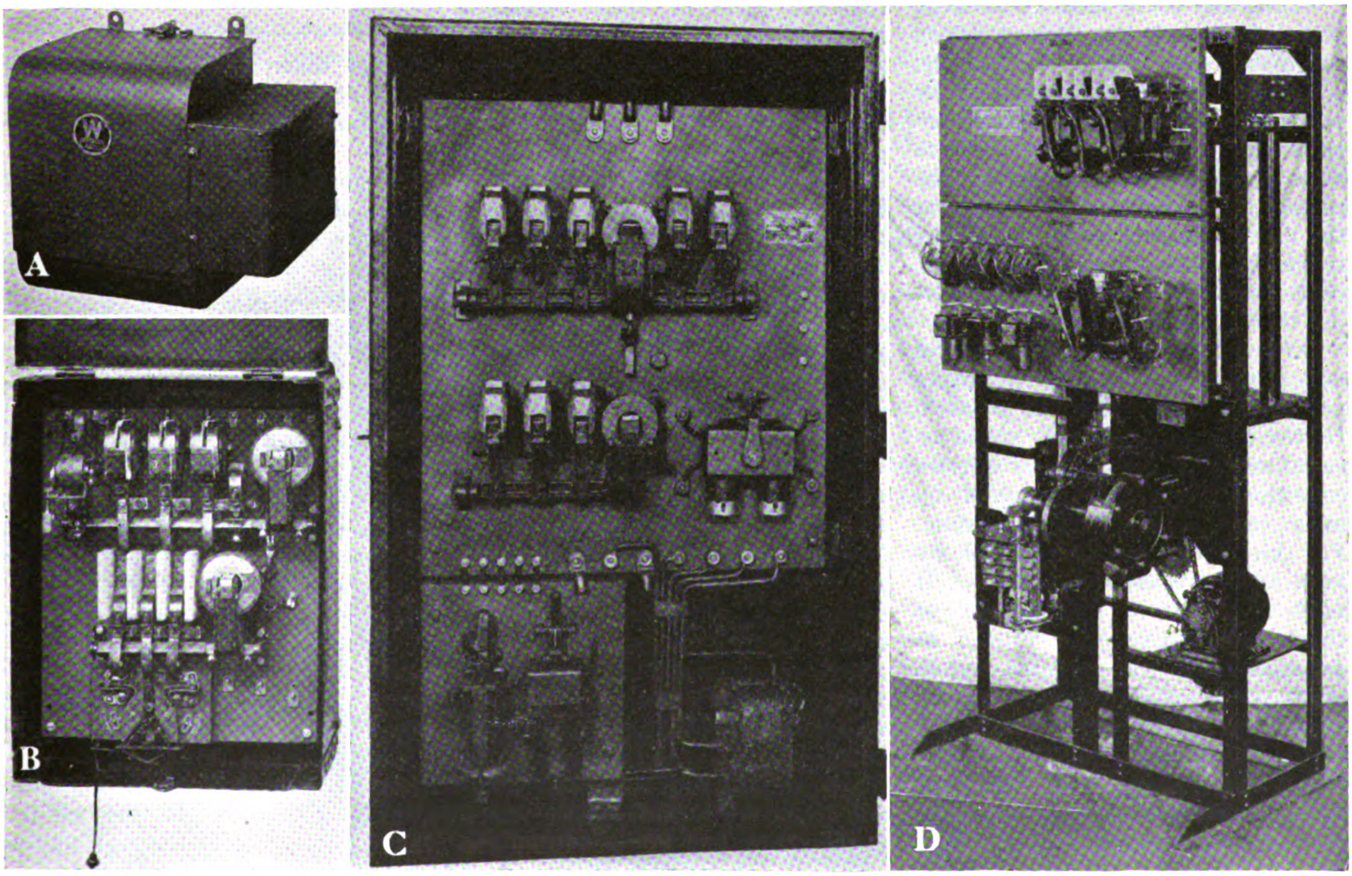
Recently, some motor manufacturers have been experimenting with squirrel-cage rotors having two windings. One is a high-resistance winding which is close to the surface of the rotor and has a high resistance so as to give good starting characteristics. The second winding is embedded in the iron and absorbs very little power at slow speeds on account of the inductive effect of the iron surrounding the conductor. As the motor approaches full speed this winding takes the load on account of its low resistance and serves as the operating winding, practically short-circuiting the high-resistance winding on the surface of the rotor. By changing the proportions of these windings the speed-torque curve of the motor can be given a variety of shapes. Experience with this type of motor is, however, too limited to make any predictions regarding its general use. It has the advantage that the motor itself has the necessary features for limiting the inrush current at the time of starting and, therefore, a much simpler form of controller can be used.

Much has been said regarding the effects of open circuit transition from the starting to the running point in many auto-transformer starters. For most motors under 200 hp. such a discussion is largely academic.

The writer believes that the real reason for selecting one type of reduced voltage starter rather than another, is simply a matter of cost and convenience. The resistor starter is a power consuming device. For small motors which may be started at 80 per cent of normal voltage the energy lost in starting is small and the resistor type of starter is not bulky. Larger motors require starters which will reduce the voltage to 65 per cent of normal, which makes a much larger resistor type of starter. For some applications 65 per cent of full voltage will not start the motor, so that it is necessary to obtain permission to use 80 per cent of full voltage for starting. Standard starters should, therefore, provide both voltages, particularly for motors of 25 hp. or larger. This means a rather large resistance starter.

The transformer type of starter has relatively small losses and can be made compact and of a convenient shape. It is, therefore, the most desirable type for many applications.

In general, either type of starter may be used within certain limitations. The convenience to users, however, will probably be the controlling factor rather than the power consumed during starting or the question of open-circuit transition from starting to running.



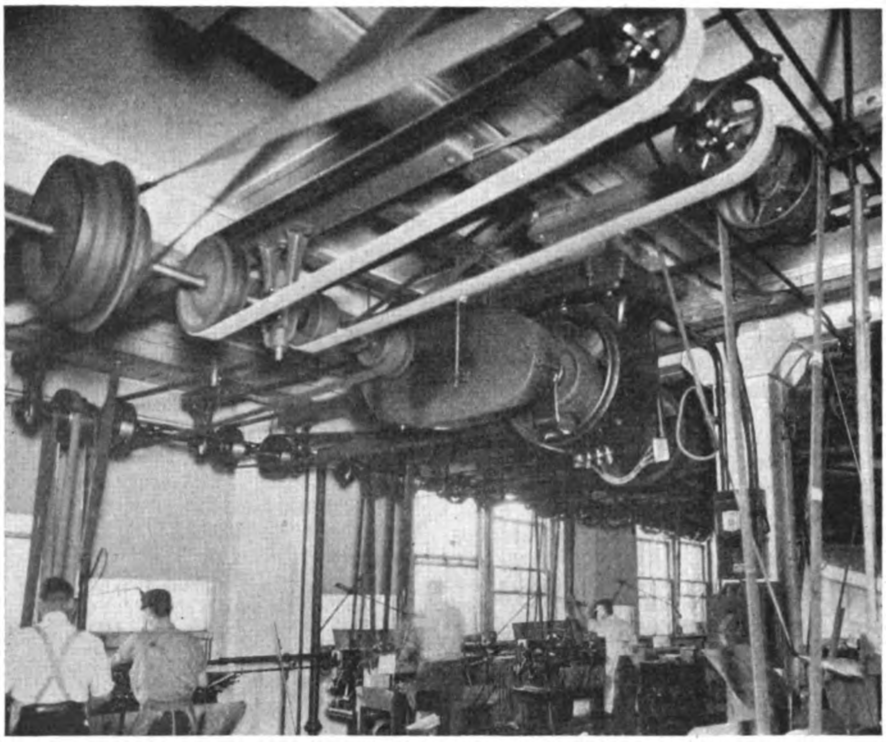
Push button operated automatic starters for squirrel-cage motors.

At *A* is shown a Westinghouse automatic auto-starter or compensator. The smaller case at the right contains a magnet which furnishes the motive power for operating the oil switch in the bottom of the larger case. In *B* is shown the General Electric automatic compensator. The switching, as can be seen, is done by air-break contactors. This starter has a thermal overload relay, shown at the bottom of the illustration. *C* shows a Westinghouse automatic compensator using air-break switches. The auto-transformer can be seen at the lower left. At *D* is shown an Allen-Bradley, gradual start, automatic, primary resistance starter. The timing and sequence of operations on this starter are controlled by a pilot motor driving a drum controller and a cam for varying the resistance, in conjunction with time and current accelerating relays.

Some examples of

Silent Chain Drives on Industrial Equipment

including an analysis of the reasons for using such drives, and the operating results obtained from them



One of five silent chain drives in the screw-machine department of The Addressograph Company, Chicago, Ill.

Several years ago The Addressograph Company installed a Link-Belt silent chain on one of their lineshaft drives in the screw machine department and have since adopted chains for all similar drives in this department. One of the reasons for doing this was the desire to get a definite and unvarying speed of the lineshaft, as the operation of the screw machines is based on the speed of the lineshafts, which are operated at 208 to 220 r.p.m.

By FRANK E. GOODING

Associate Editor, Industrial Engineer

INDUSTRIAL plant operating men find that most power transmission drives operate with very little trouble. This is often due to a light load or to ample provision in the power transmission equipment to take care of any load.

Practically every medium or large plant, however, has drives which continually give trouble. Frequently, on drives which do not operate under severe service conditions, this unsatisfactory service has been due to an attempt to save by estimating the rating too closely when designing the drive. In such cases, providing transmission equipment of ample capacity is the only means of solving the problem.

On many types of drives the load is of a fluctuating, or pulsating nature or is in the form of a shock. Drives of a rating which would be satisfactory under ordinary service conditions often do not stand up under more severe variable loading. For this type of service many plants have applied silent chain drives. It must be admitted that not all of these installations have proved as satisfactory as was expected, but in most cases an investigation would show that the trouble was not due to the chain itself but to the way that it was applied. One of the most common causes of trouble is neglect to take into account the fact that extraordinary service conditions require an extra capacity in the chain.

Air compressors and refrigeration machinery represent a heavy type of service. When motors were installed on compressors in service to replace the steam engine drive many plants installed silent chain drives on them. This permits putting the motor up close to the compressor and gives a constant ratio of speed reduction irrespective of whether the compressor is operating under an overload or with a light load. This latter advantage has become one of the important advantages of chain drives in that a definite number of revolutions of the driven machine result from each revolution of the driver. This is also one of the principal reasons for the adoption of silent chain drives on many other types of equipment. An installation with a motor drive on a two-stage air compressor connected by a Link-Belt silent chain is shown on page 10.

Still another operating condition which puts a very heavy load on a chain drive is in connection with a lineshaft drive to the tumbling barrels in a foundry. As the barrels revolve, the contents roll and shift, thus causing intermittent jerks, which are transmitted back to the drive. In such cases, care must be exercised to see that the drive is of sufficient capacity to take care of the shock of the shifting load. Such over-loads are strains on the metal in the chain, and this condition can only be taken care of by providing capacity in the chain sufficient to withstand the load without undue stress.

A good example of a tumbling barrel drive is shown on page 12. Here the lineshaft is connected to a battery of 12 tumbling barrels and is driven at 100 r.p.m. by a 565-r.p.m., 25-hp. motor, through a Morse chain in the plant of the Towner Mfg. Co., Cleveland, Ohio.

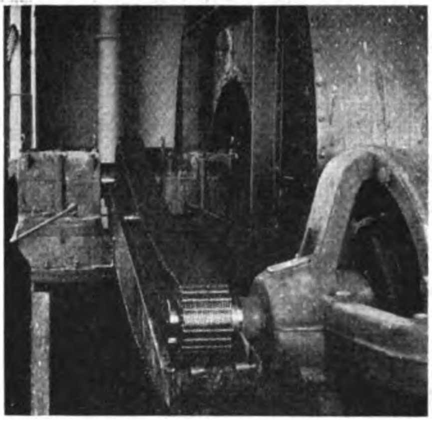
Blowers and ventilating fans are still another type of severe service which taxes the drive connected to them. Ordinarily chain drives for this and practically all other types of equipment are mounted with a comparatively short center distance which is determined approximately by the pitch and the diameter of the sprockets. In the installation pictured at the top of page 9 an induced draft fan operating at 300 r.p.m. is driven through a Ramsey silent chain by a 30-hp. motor operating at 750 r.p.m. In this case the fan was so close to the wall and so

large in diameter that the motor had to be installed entirely beyond the fan. This made it necessary to operate the drive on 84-in. centers.

Chains are coming into wide use on conveyor drives as they can be connected up to give a considerable reduction in speed on the first step. One of the illustrations on page 10 shows an American High Speed chain driving a pan elevator conveyor over 100 ft. long for handling sand. This is driven by a 200-hp., 720-r.p.m. motor with a step down to 235 r.p.m. for the driven shaft. The remainder of the reduction is through gearing. This 200-hp. drive consists of two strands of 1¼-in. pitch chain; each strand is 12 in. wide.

A type of drive somewhat similar to a conveyor drive, in that there is a considerable reduction in the speed of the driven equipment, is used on the traveling ovens in biscuit and cracker bakeries as is shown on page 12. In this case a 7½-hp. motor is connected to a Reeves variable-speed drive by a Ramsey silent chain to give a speed reduction in the first step of 1,150 to 355 r.p.m. The chain is operated on 30-in. centers.

In the larger proportion of cases chain drives are designed for stepping down the motor speed instead of stepping it up. However, in the Chicago plant of a candy manufacturer, a sugar pulverizer, operating at 3,600 r.p.m., is driven from a motor operating at 800 r.p.m. This gives a step-up in the speed ratio of 4½ to 1. The motor shaft is extended at both ends and a sprocket is also placed on each end of the shaft, which connects through the chain to the pinion at the end of the pulverizer shaft. A 35-hp., 800-r.p.m., 220-volt, d.c. motor is used on this drive, which is shown on page 11. The shaft and rotating parts in the pulverizer weigh somewhat over 300 lb. and must be very carefully balanced. A Morse chain is used.



Ordinarily silent chain drives are operated on short centers, but this drive is on 84-in. centers

Because this induced draft blower was placed so close to the wall that the motor could not be installed alongside it, the long center was necessary. This blower is driven by a 30-hp. Ramsey silent chain.

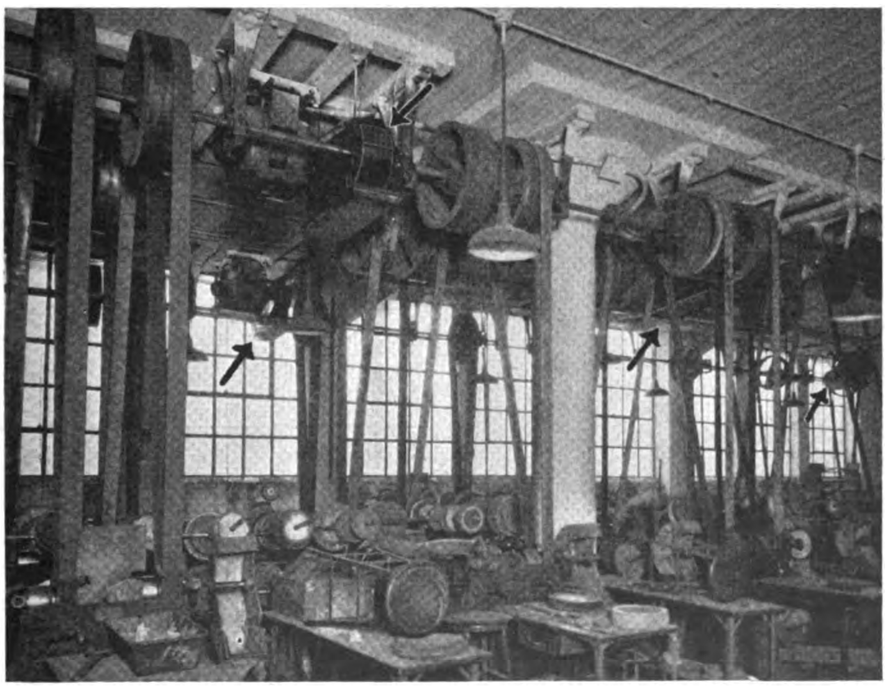
SKF thrust bearings are placed at each end of the shaft and operate under continuous lubrication from a sight-feed oil cup. Plain ball bearings are used for the radial support of the pulverizer shaft in the bearings located between the pinions and the rotating part. The guard on the chain was removed when this photograph was taken.

To operate this shaft at 3,600 r.p.m., it is necessary for the chain to travel at a very high speed, and in order to insure satisfactory operation it was necessary that the chains be placed in special relation to each other. The keyways in the sprockets and pinions were cut very carefully and centered on the center line of a tooth. The sprockets on each end of the shaft were also lined up and cut as accurately in line as possible. This was necessary because if one chain were pulling just a little ahead of the other there would be a noticeable whip in the chain, which, at the high speed, would give very unsatisfactory operation. The installation as originally made operated very satisfactorily. However, after it had been in operation for some months, the shaft in the pulverizer was accidentally bent. In installing the new shaft the keyways were cut a fraction of an inch out of alignment. This caused one chain to pull a little ahead of the other and, due to the high speed of operation, resulted in a very serious whip in the chain. When a new offset key was made and installed, which takes care of misalignment of the keyway, the pulverizer operated as well as before.

This chain is lubricated by applying oil to the back of the chain with a brush, about once a month. The small pulley placed on the end of the motor shaft, as may be seen in the illustration, drives a countershaft overhead which is connected to the elevator, that supplies sugar to the pulverizer, and to the blower which blows the pulverized sugar into the bags of the centrifugal separator.

Before the chain was installed, this pulverizer was driven from the same motor by two special, rawhide belts on 18-ft. centers. The installation of the chain, of course, reduced considerably the floor space required. Previously there had been a great deal of difficulty in keeping the tension of the two belts identical, so as to obtain a positive, even drive on each end of the pulverizer.

When the tension on one belt exceeded that of the other, the result was the same whip as when the

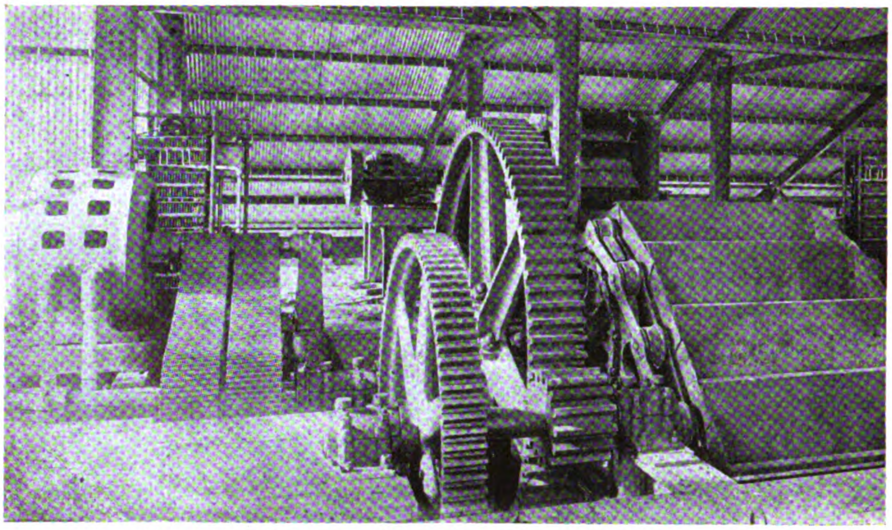


Four silent chain drives are used in this installation.

The two lineshafts in the foreground are operated at 500 r.p.m. from a motor connected through a short-center American High Speed silent chain. This is an installation of brass polishing and buffing wheels at the plant of the Chicago Faucet Company. The other two lineshafts operate at a lower speed.

This 200-hp. chain drive is connected to a pan elevator conveyor.

This drive is used to handle sand on an elevator over 100 ft. long. The 200-hp. American High Speed silent chain is made up of two strands of 1¼-in. pitch chain each 12 in. wide and connects a 720-r.p.m. Allis-Chalmers motor to a shaft operating at 235 r.p.m.



two chain sprockets were slightly out of alignment. The life of these two rather expensive belts was short, which made the drive a very expensive one. The chain has been in operation now over a year and a half and has not caused any trouble except during the few days after the new shaft was installed, as has already been explained.

In making this installation, an additional allowance was made above the 17½ hp. for each chain which would normally be considered sufficient for operating the drive, as the motor is rated at 35 hp.

Another interesting experience with a silent chain drive occurred in a lead mill. Previous to 1908, the method of driving the high-pressure hydraulic pumps used in the operation of lead pipe presses at the Chicago plant of the Raymond Lead Works, had been a source of considerable trouble. It was practically impossible to prevent some water leaking from around the pistons and getting onto the belts.

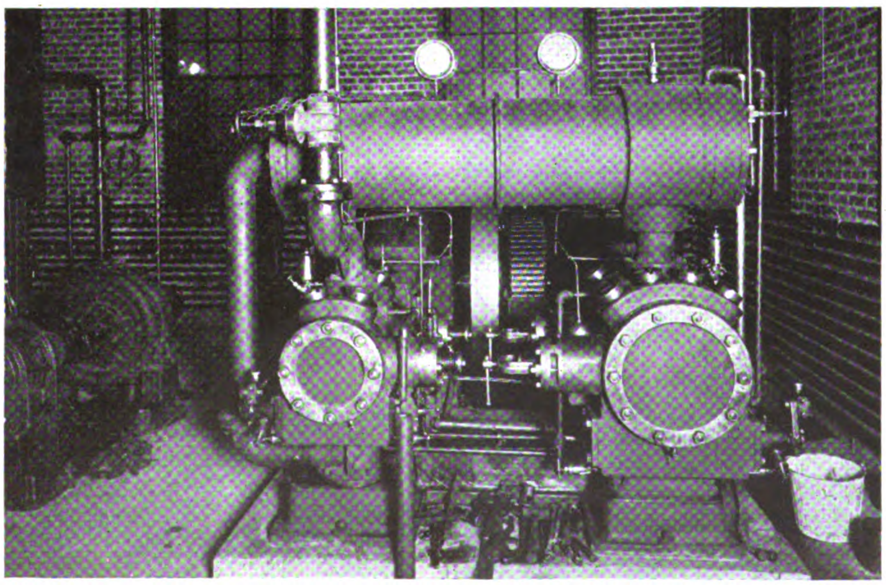
In 1908 at the recommendation of Earl C. Moss, consulting engineer, Chicago, Ill., Morse chains were installed on each press pump lineshaft, which in turn were driven by two 50-hp. motors through belts. These chain drives have operated at practically no cost and with very little attention until 1924 and 1925 when some of the sprockets, some links, and one or two of the chains had to be renewed.

In addition to this, two sheet lead rolls are also driven by silent chain. In these mills both rolls reverse; that is, the motor reverses at the end of each pass and the sheet is returned through the rolls. One of these mills is operated by a 75-hp. motor and the other by a 50-hp. motor. Both of these drives have stood up well under the strain of the rapid reversals.

In heavy-duty work such as on pumps and on rolling mill drives much depends upon using a chain of ample size for the heavy duty involved. The overloads are momentary and the motors are always designed with an ample factor of safety for such service. The point which too many users of silent chains overlook is that the chain also must be of a capacity fully capable of standing the overload which might be placed upon it. It must be remembered that electrical apparatus shows the effect of overloading largely by heating and unless the overload is continuous or far above the capacity of the equipment, no serious results follow. On the other hand, the mechanical elements of a drive have a specific stress or load rating above which it is not advisable to go. For this reason while a motor is capable of handling a temporary overload of 50 per cent, it is never advisable to use a chain which is so small that it may be subjected to a 50 per cent overload. In such cases, a chain of 50 per cent greater capacity will give much more satisfactory service and is always advisable. This is also true of all other mechanical elements in a drive, such as gears, clutches, couplings, or other auxiliary parts of the drive.

In the Chicago plant of Philip Ruxton, Inc., manufacturers of printing inks, Link-Belt silent chain drives have supplanted gears in connecting the motors to the ink rolls. The motors are mounted on the floor alongside the machines. An ink roll consists of three rolls geared together, and operated separately at ratios of approximately 1:3:9, in ordinary practice.

These rolls are so close to each other that some provision must be made to stop the machine quickly if any foreign matter should get into the rolls. This is done through the shearing pin in the drive gear. If even a wiping rag should get in



Compressor drives such as this, operate under severe service conditions.

This is a two-stage, cross-connected air compressor drive which is connected to the motor through a Link-Belt silent chain. Due to the severe service under which a compressor drive operates, an additional horsepower rating according to a service factor is required when designing the drive.

between the rolls the extra load would shear the pin and so stop the machine. The gear would continue to revolve on the shaft, but the connection between the gears and the shaft would be broken.

These drives have been in use for several years with only an occasional renewal of a link. The drives are not totally inclosed and so do not operate in a bath of oil; however, they are lubricated frequently by brushing the backs of the chain with a brush dipped in oil. The manufacture of ink does not create dust which can get into the chain. Each machine has its own speed reduction, which is not uniform on all machines; most of them, however, operate at a reduction of approximately 1 to 4 or 1 to 6. The load on this service is very constant, particularly as some of the mills operate almost continuously.

Another ink manufacturer uses a variety of drives according to the special problems involved in the work. In the main factory where inks of standard colors are produced in large quantities and the mixing rolls are operated almost continuously, the machines are driven from lineshafts. Under such conditions lineshaft drive with belts to the rolls is considered more economical.

In the branch factories, however, the larger proportion of the work consists of small runs to prepare ink of special colors to match samples. These runs are comparatively short with considerable idle time in between for cleaning up the machine before the next run. For this reason it has been considered more advisable to use an individual drive on each machine. Originally, belt drives on above 10-ft. centers were used in one of the plants. These, however, occupied considerable floor space. As it was desired to economize on floor space and add additional mills, each mill was changed over to a short-center, American High Speed chain drive.

Another interesting application of chain drive is in connection with some special machines for polishing reflectors for floodlights at the Chicago plant of The Pyle-National Co. These machines consist of a number of spindles or heads driven by a single motor. With the older type of machine, these spindles were each driven through a gear. However, the abrasive material used in the polishing process soon wore out the gears, so that they quickly became noisy.

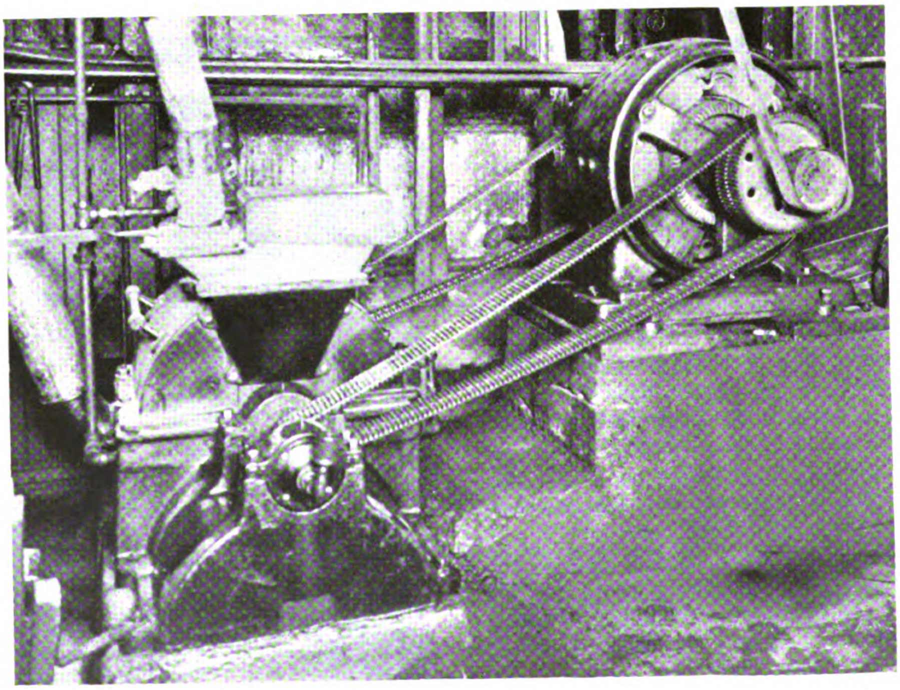
The machines have all been redesigned, so that instead of gearing each spindle is driven by a Link-Belt silent chain. The chain drive is not only quiet, but it has been found that the wear is much less and the life of the chain and its sprockets is considerably longer than was the case with the gears. The chains are subjected to moisture and abrasive material, and operate under practically the same conditions as did the gears.

Several years ago The Addressograph Co., Chicago, Ill., installed a Link-Belt silent chain on the lineshaft driving a battery of screw machines. The advantages found to result were a decrease in the maintenance cost and attention required by the drive. Formerly the belt had to be tightened frequently and occasionally the group of machines had to be shut down to repair the drive. This left the men idle in the meantime. When belts to the individual machines require attention only the one machine is interfered with; any interruption on the main drives stops all. Since then four other batteries of screw machines have similarly been equipped with Link-Belt chains on the lineshaft drives.

Another advantage of chain drives, which has been of value in the experience in this plant, is that a chain gives a positive reduction in speed. Here fixed lineshaft speeds, which range from 208 to 220 r.p.m. are used on the different drives. These speeds are used in determining what output should be expected of any machine and in setting the speed and feed gears of the screw machines. The chain dips in a bath of oil in the lower half of the case.

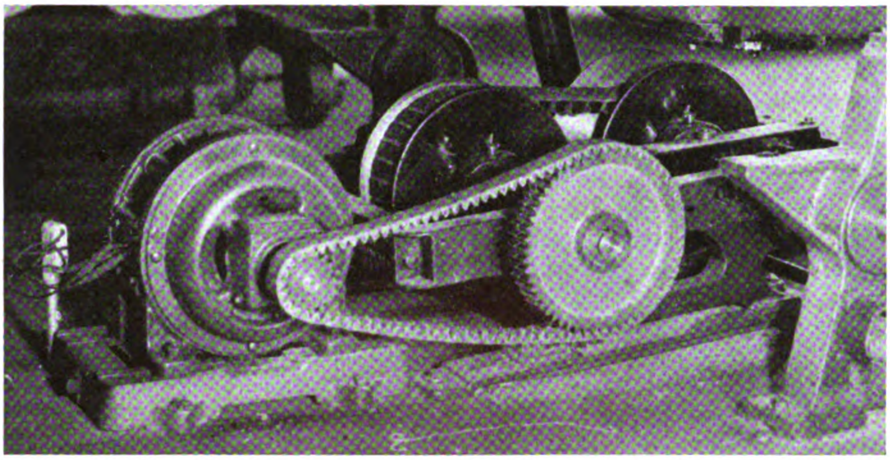
On lineshaft drives it is often necessary or advisable to make the lower part of the chain case hinged and fasten the upper half to the ceiling because generally the upper part of the case cannot be lifted high enough to permit inspection.

Buffing or polishing wheels are generally operated from lineshafts or are individually motor-driven. As the wheels operate at high speed, the lineshaft is usually driven at a speed much higher than in the case of the ordinary lineshaft installation. In the plant of the Chicago Faucet Co., short lineshafts are connected to groups of eight buffing or polishing machines. The lineshafts are driven by 15-hp., 1,200-r.p.m. induction motors and operate at 500 r.p.m. SKF ball-bearing hanger boxes are used throughout. The motors are mounted on the ceiling and are connected to the lineshaft by American High Speed chains. The principal reason for using chain drive was the difficulty of operating belts and pulleys in the heavy atmosphere of abrasive dust which would



On this drive a silent chain is used to step up the speed.

In a Chicago candy factory a sugar pulverizer is operated at 3,600 r.p.m. by a 35-hp. motor. The pulverizer is driven through Morse silent chains at each end of the head by a motor with an extended shaft. It was necessary in this case to line up the keyways in the shaft and in the sprockets so that the teeth would be in perfect alignment and fit into both chains simultaneously.



A type of drive installed as standard by a large manufacturer of biscuits and cookies.

Here a 7½-hp. Ramsey silent chain is connected up to a Reeves variable-speed drive to give an immediate reduction of 1,150 r.p.m. to 355 r.p.m. This drive operates on 30-in. centers. The variable-speed drive permits a large variation in the speed of travel of the oven, to take care of quick- or slow-baking products.

settle on the belt and act like emery on the pulleys. These chain drives are totally enclosed and dip in lubricant in the lower part of the case.

In another factory groups of light punch and forming presses are operated from lineshafts. Two shafts are driven by 20-hp. motors and two other shafts are driven by 15-hp. motors connected to the shaft by American High Speed chains. The shaft operates at about 275 r.p.m.

Silent chains were used on this installation because it was desired to have the shafts operate at a very definite speed, which would be known to be exact when determining the speed of operation of each individual machine. Before the chain drives were installed the lineshafts operated at speeds lower than was thought to be the case, and so production figures based on the estimated speed of the lineshaft were in error by several percent. In some cases this had been caused by using pulleys which were available and would give what was considered to be "approximately" the right speed.

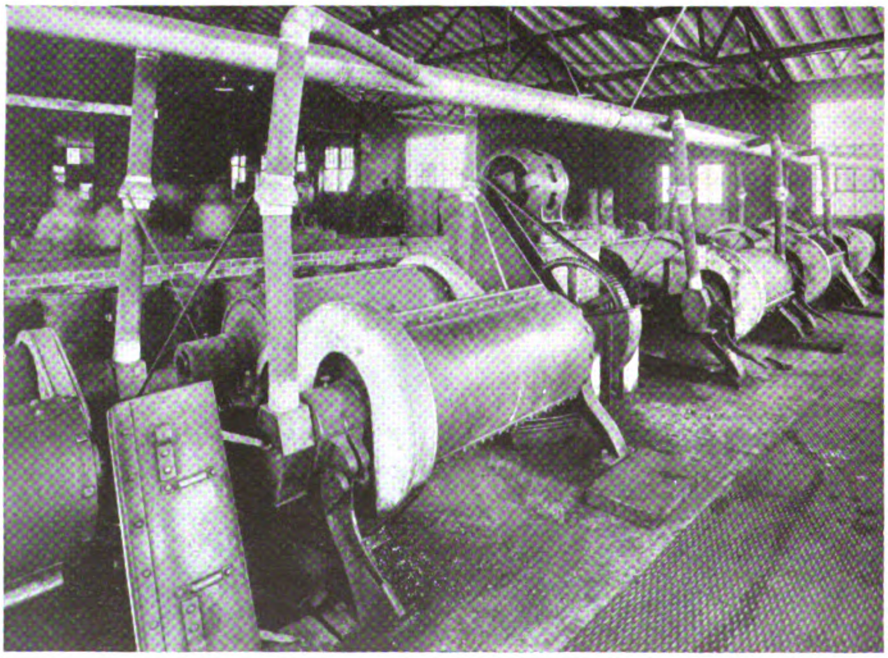
A manufacturer of envelopes has installed a number of ½- to 2-hp. American High Speed chain drives on various machines in his plant. Most of these chain drives replaced gear drives which became very noisy as soon as the gears were slightly worn. As most of the help in plants such as this is composed of girls and women, quiet operation of equipment is a very important factor in keeping the better class of workers.

The first of these chains was installed about four years ago and additional chains have been put on various machines since then, as they have been taken down for overhauling. Some of the motors operate at 1,750 and others at 1,200 r.p.m. Reductions of 3 to 1 and higher are made on the various drives. On one of the first machines on which a chain drive was installed, the motor previously had been mounted about 5 ft. away to one side of the machine so as to give room for the belt drive. This arrangement prevented the operator from passing around the machine except on the one side and also occupied considerable floor space. A new sprocket was placed on the shaft and the motor brought up and mounted directly under the machine and connected to it by a short chain drive. The end of the shaft which extended out from the side of the machine to carry the belt pulley was cut off and the operator can now pass around the machine on either side, which permits him to operate two machines. Expansion of the department made it necessary to shorten up all of the drives to gain additional floor space so that now all machines are chain driven.

A number of other machines were connected to the motors directly through gears. A set of gears would last from a year to a year and a half, when, due to the abrasive action of the paper dust which would get into them, they had to be renewed. A set of gears and pinions for a drive cost $14, while the sprocket and chain for a similar drive cost $16; that is, the cost of the gears was about $10 a year, compared to a cost of $16 for the chain spread over several years.

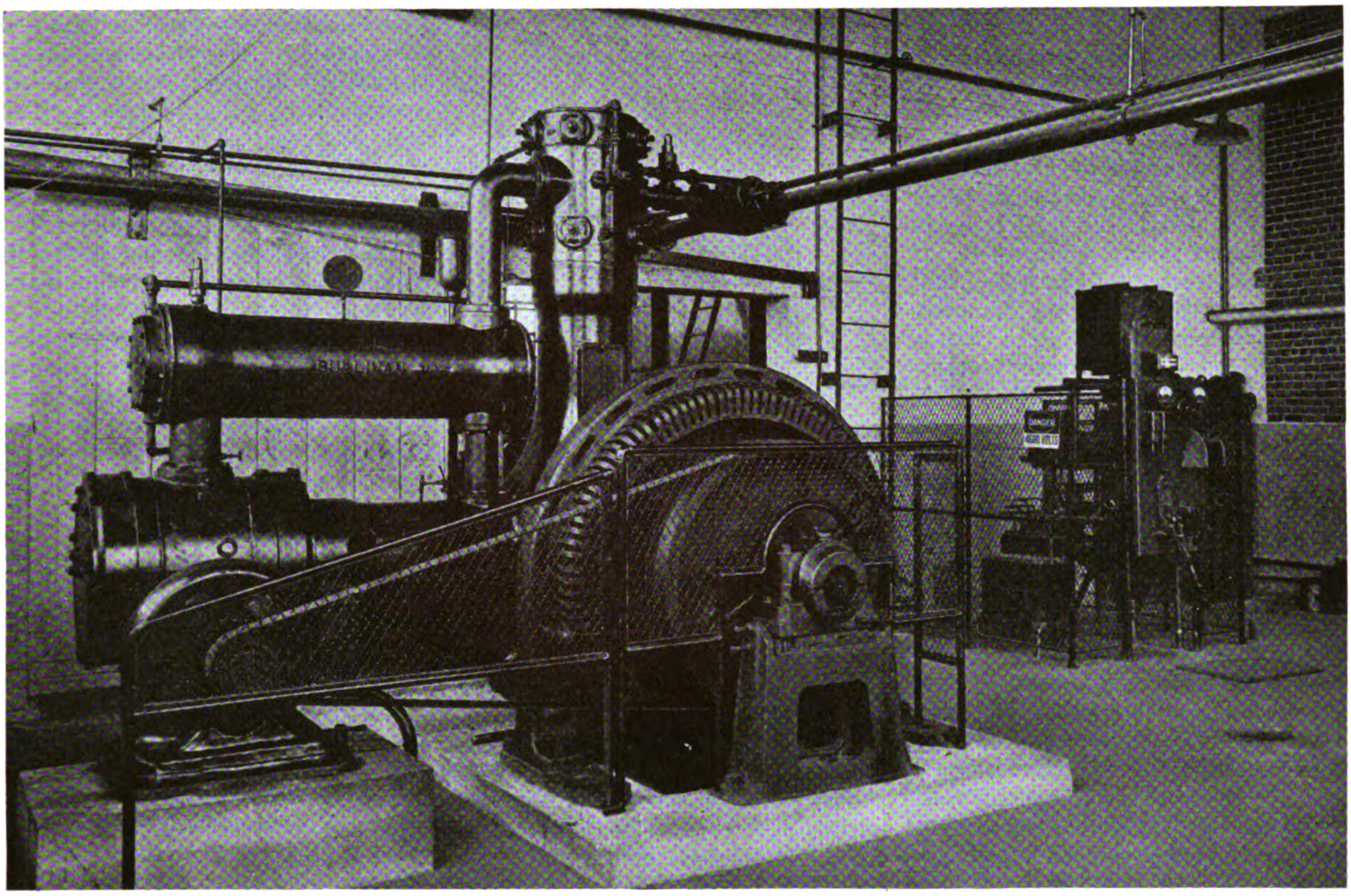
These chains are set back under the machine sufficiently to be protected and prevent paper from getting down into them. When the machines are idle on Saturday afternoons, a man wipes paper lint off all drives and oils the chains from the back with a brush.

Shearing pins are a part of each driven sprocket. This is especially necessary in envelope cutting machines where there is always the possibility of something getting into the way of the die and stopping the machine during the stroke.



Due to the shock load a tumbling barrel drive presents unusual operating conditions.

This battery of 12 tumbling barrels at the Cleveland, Ohio, plant of the Towner Mfg. Co., is driven through a lineshaft by a Morse silent chain connected to a 25-hp. motor operating at 565 r.p.m. This is a 1.2-in. pitch chain, 4 in. wide, operating on 54-in. centers.



The synchronous motor is pre-eminently adapted for the great majority of air compressor drives. In this illustration a synchronous motor is direct connected to a Sullivan Machinery Co. angle compound (two stage) compressor. Manually-operated control (shown at right) is used for starting. This installation is in the plant of the Enterprise Foundry Co., at Detroit.

Factors to consider when selecting

Power Drive Equipment for Air Compressors

including type and capacity of motor required, kind of control apparatus necessary, and the type of mechanical connection that should be used for coupling the motor to the compressor

By GORDON FOX
Electrical Engineer, Freyn Engineering Company, Chicago, Ill.

MANY and varied are the uses of compressed air. Industrial uses of this form of power are confined mainly to furnishing the motive force for portable tools such as drills, reamers, hammers, and riveters, as used for steel fabrication, miscellaneous factory maintenance, and quarrying; for air hoists and air chucks as used in machine shops; for sandblasting and for general cleaning of electrical and mechanical equipment; for paint sprays or mechanical painting devices; and for the agitation and propulsion of liquids and semi-liquids found in some industrial and chemical processes.

Inasmuch as compressed air can be readily carried through pipes to the point of consumption it is the more common practice to compress the air at one or more central locations which are connected to a pipe distribution system. Compressors are located near points of large air consumption and the pipe lines carry the air to any other places where use of it may be required.

Selection of the motor, control, and mechanical power drive equipment for an air compressor depends upon many factors, among which are type of compressor, character of load, method of unloading, pressure required, speed of compressor and the like. An understanding of the types of air compressors will aid in the proper application of power drive equipment to them.

For compressing moderate volumes of air at fairly high pressures, compressors of the reciprocating, displacement type are particularly suited.

Single-stage compressors are in common use in the smaller sizes and for the lower pressures. These are ordinarily single-cylinder machines. Two-stage compressors are employed in the larger capacities and for the higher pressures. These are commonly duplex machines with cranks 90 deg. apart. Single-stage compression is properly employed for gage pressures up to 60 lb. per sq. in. For pressures from 60 to 100 lb. per sq. in. the selection of the compressor

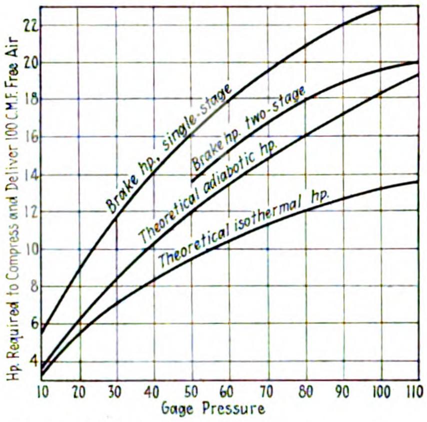
should be governed by the capacity, the altitude, and the cost of power. For discharge pressures above 100 lb. per sq. in., two-stage compressors are considered standard.

The compression of air develops heat. As the air cools before being used, this heat is lost and leads to shrinkage of the air compressed. If air is compressed adiabatically, that is, with no cooling during compression, more power is required than if the air were compressed isothermally, that is with sufficiently cooling to maintain constant temperature through the compression operation. However, it is not possible to accomplish isothermal compression. As an approach to this condition, water jackets on the compression cylinders are employed, together with multistage compression having inter-cooling coils between stages.

For the reasons just stated, two-stage compression is materially more efficient than single-stage compression. The difference is more pronounced the higher the ratio of compression. For pressures above 60 lb. per sq. in. two-stage compression is preferable. In case of high altitudes the ratio of compression is increased and the benefit of two-stage compression is enhanced. The higher efficiency of the two-stage machine lowers the power consumption, which may permit the use of a smaller motor. The saving in motor cost resulting thereby, may partially offset the higher cost of a two-stage compressor. Two-stage compression is generally to be preferred for pressures of 100 lb. and above with displacements of 300 cu. ft. of free air per min. and above.

Power Required to Drive Reciprocating Air Compressors

The power required to drive a reciprocating air compressor depends upon the size, type, ratio of compression and many design details. Average conservative values of brake horsepower at the compressor shaft per 100 cu. ft. per min. of free air delivered, are given both for single-stage and two-stage compressors in the diagram on this page. This diagram also shows the theoretical power requirements for adiabatic as well as for isothermal compression. The overall efficiency of commercial single-stage compressors, referred to isothermal compression is on the order of 60 per cent. The over-all efficiency of two-stage compressors is more nearly 65 to 70 per cent. In



Brake horsepower required at compressor shaft per 100 cu. ft. of free air per min.

Values are given for both single-stage and two-stage compressors for gage pressures from 10 to 110 lb. per sq. in. Comparative adiabatic and isothermal compression power requirement curves are shown.

the case of belt-driven compressors some allowance should be made for belt losses in arriving at the horsepower required at the shaft of the motor.

The values shown in the diagram on this page refer to sea level conditions. In the case of high altitudes the ratio of compression and the mean effective pressure are increased and the power required per cu. ft. of free air per min. is greater. However, the capacity of a given compressor is reduced to a greater degree than the increase in unit power requirement. Therefore, an equipment which is correct under sea level conditions may be overmotored at high altitudes. The table on page 15 shows the corrections to be made for altitude. The factors given in the last column of the table should be used in correcting the curves in the diagram on page 14 so as to make allowance for different altitudes.

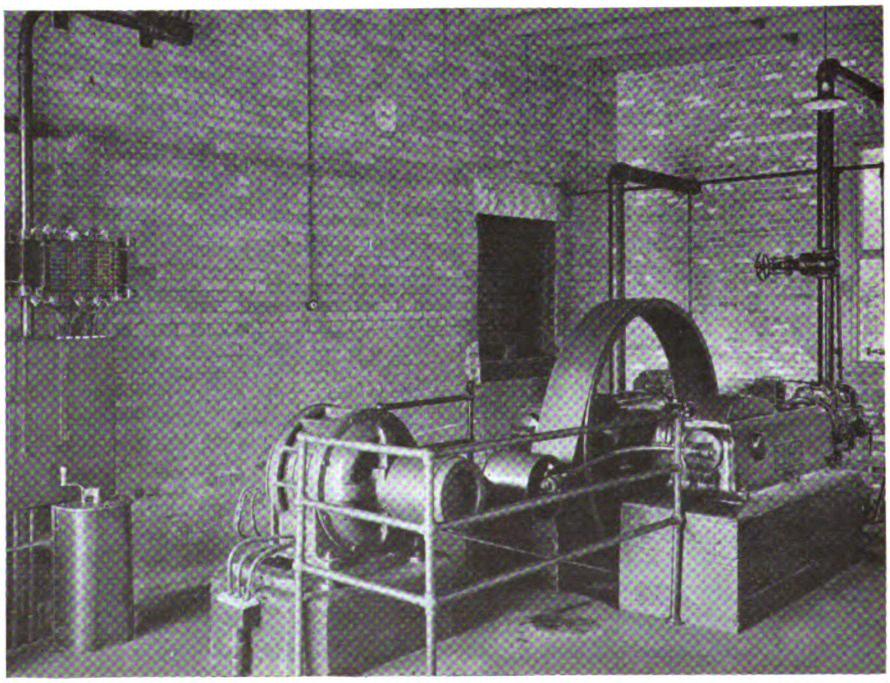
The power consumption of compressed air systems may be seriously affected by leakage. To avoid excessive power wastage from this cause it is desirable that the tightness of the air lines be tested frequently by noting the rate of drop in pressure when all legitimate uses of air are temporarily discontinued.

The reciprocating compressor, a positive displacement machine, delivers a definite quantity per revolution. It is thus possible to vary the delivery by changing the speed. In this case the torque maintains a definite value and the horsepower required increases directly with the speed. With steam engine drive the speed is commonly varied to give the delivery required.

It is usually desirable to drive air compressors by alternating-current motors because, (1) power is generally available in this form and is cheaper, (2) avoidance of conversion loss, (3) fairly large amounts of power are commonly involved, and (4) because alternating-current motors are excellently suited to the work. As the alternating-current motor is inherently a constant-speed machine several methods have been

A short-center belt drive gives a very flexible and economical arrangement.

This Ingersoll-Rand two-stage, air compressor is driven by a wound-rotor induction motor. A manually-operated drum controller, as shown at the left is used for starting.



developed to vary the delivery of compressors driven at constant speed, in order to adjust the output to the demand.

Methods of Taking Care of Irregular Air Demand

Where the demand is irregular but not intermittent it is best to "unload" the compressor during periods of light demand. There are several methods of unloading. In one method the admission of air is prevented and the piston is operated in a partial vacuum. However, with this method the transition from no-load to full-load may be rather sudden. To avoid this another method used prevents the admission of air and opens the discharge valves of the compressor. In the third method, the suction valves are held open during both the suction and compression strokes.

An air compressor while operating "unloaded" requires about 15 per cent of its full-load input, which represents a considerable loss of energy. Light load operation over long periods is undesirable for this reason and also because of the low power factor resulting when induction motor drive is used.

Air compressors are now available which do not unload entirely and suddenly, but partially, by steps. These can be operated steadily at partial output, if desired, rather than intermittently unloaded or with full output. The more common method of providing partial unloading is by means of variable clearance regulation in which auxiliary valves open auxiliary clearance pockets. Other methods of partial unloading are by variable compression volume and variable suction volume. Partial unloading gives a more uniform motor load and may lower the power demand peaks where demand is determined on a two- or three-minute interval. Where demand is determined by an integrated consumption over fifteen minutes or more, partial unloading will not decrease the demand.

Where the demand is highly intermittent, it is not desirable to operate a compressor unloaded for long periods. It is then best to arrange for the motor to start and stop, as required, to maintain the pressure within limits in a storage receiver. Automatic magnetic control in connection with a pressure gage governs the motor operation. The illustration on page 16 shows such a method of control in use on a two-stage tandem compressor.

In air-compressor applications where a system is operated in this manner it is necessary that there be little leakage; otherwise the compressor will be called upon to operate from time to time when no air is being used, merely to supply the leakage. It is quite feasible to store a large supply of air in a receiver, the latter serving primarily to prevent too frequent starting and stopping of the compressor due to leakage in connection with a piping system of small volume.

Some compressors are installed under conditions where the demand for air may be highly intermittent during portions of the time and fairly heavy during other portions. It is not desirable to operate by the automatic start and stop method if the demand is such that the compressor is thereby started and stopped too frequently. It is often feasible to provide the compressor with unloading devices and also to arrange the control for automatic start and stop operation. Means may be readily provided for by-passing or cutting out either system. The compressor may then be operated with the unloading device during periods of heavy demand while the automatic start and stop system may be employed during long periods of light demand.

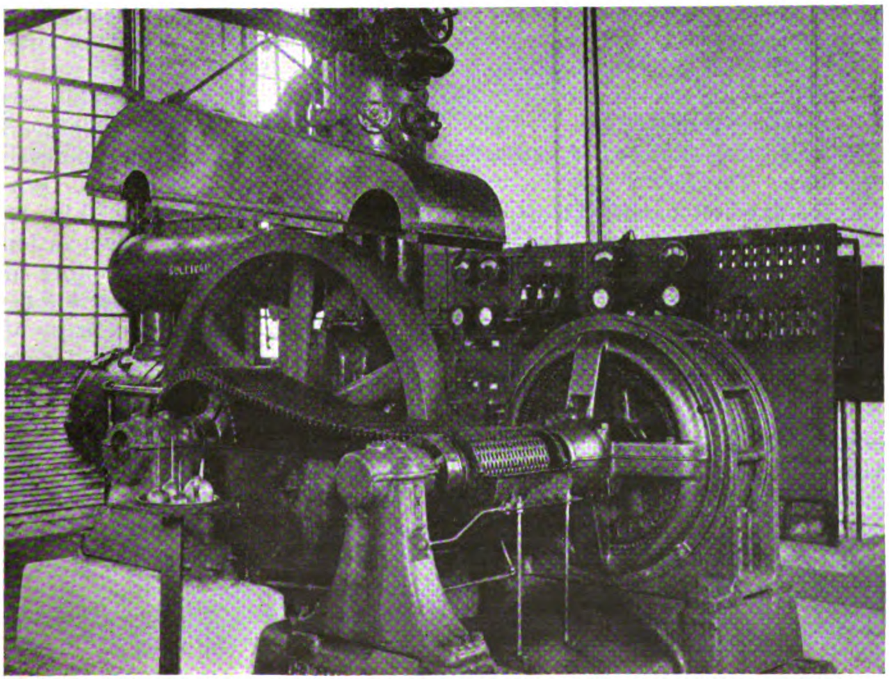
Motors driving air compressors equipped with unloading devices are limited as to loading and, therefore, require no overload capacity. Hence, drives of this type may be closely motored.

The rotative speed of a compressor is limited by the permissible linear speed of piston travel, which ranges from 300 to 550 ft. per min. The older compressors, suited for engine drive, commonly operated at low rotative speeds and had a long

Correction in Power Requirements of Air Compressors Due to Change in Altitude

Altitude Above Sea Level Ft.	Barometer In.	Inlet Air Pressure Lb.	Per Cent of Sea Level Delivery	Loss of Capacity Per Cent	Decrease in Power Required Per Cent	Increase in Power per 100 c. f. m. Per Cent
0	30.0	14.7	100	0	0.0	0.0
1,000	28.9	14.2	97	3	1.8	1.1
2,000	27.8	13.7	93	7	3.5	3.9
3,000	26.8	13.2	90	10	5.2	5.2
4,000	25.8	12.7	87	13	6.9	7.0
5,000	24.8	12.2	84	16	8.5	9.0
6,000	23.9	11.7	81	19	10.1	11.0
8,000	22.1	10.9	76	24	13.1	14.5

A silent-chain drive offers many advantages for connecting the motor to the air compressor.
In this illustration a Link-Belt silent chain connects a squirrel-cage motor to the compressor crankshaft. The top half of the guard has been removed to permit inspection of the chain.



stroke. Higher-speed, short-stroke machines are, in general, better suited for direct connection to motors. Air compressors of large capacity are now standard at speeds around 200 r.p.m. and smaller machines at speeds of 300 r.p.m. and above. These relatively high speeds reduce the initial cost of the compressor and drive, increase the efficiency, and simplify the provision of flywheel effect.

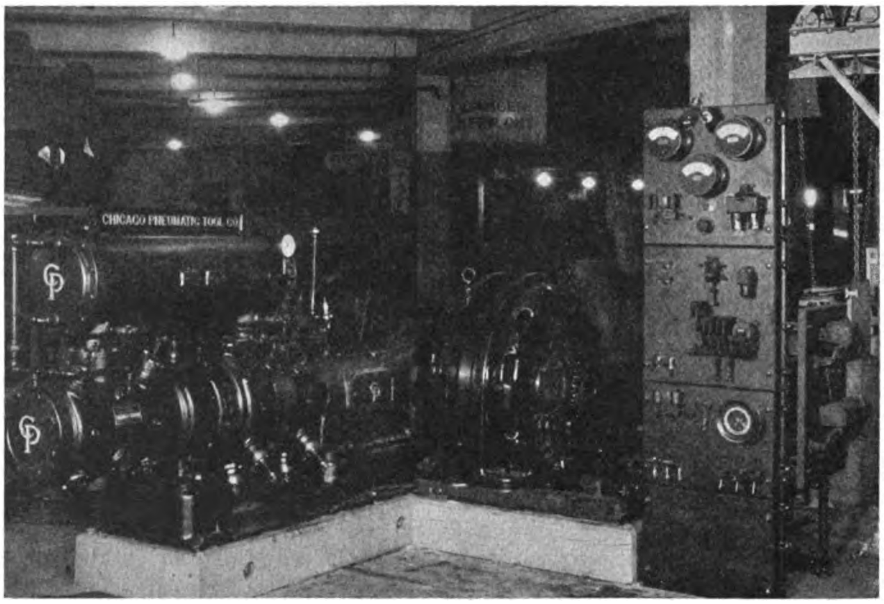
Selection of Type of Motor and Drive Connection

The synchronous motor is preeminently adapted for the great majority of air compressor drives. Except for some of the smaller units, direct-connected motors are desirable, primarily because of economy of floor space and elimination of intermediate drive mechanism. The induction motor is not commonly built for such low speeds, for at such speeds this type of motor has the disadvantages of both low efficiency and low power factor.

On the other hand, the low-speed synchronous motor is highly efficient and affords a high power factor, which is subject to control. The synchronous motor retains a good efficiency at partial loads. If excited for unity power factor at full load, the power factor will be slightly leading when the compressor runs unloaded. For the unusual, constant-speed, continuous-running duty the synchronous motor is ideal. The starting requirements can be satisfactorily met. The wide air gap of this type of motor is favorable to engine-type construction. The cost of a low-speed synchronous motor is ordinarily less than that of an equivalent induction motor. The synchronous motor is so well suited in all respects that it is almost the unanimous choice for all direct-connected air compressors and for all compressors of large capacity.

The illustration on page 13 shows a typical installation comprising an engine-type synchronous motor with belted exciter, driving an angle compound compressor. Manual switching is required for starting, however, as may be seen from inspection of the control panel at the right.

The motor may be direct connected to the compressor by pressing the rotor onto the compressor shaft, as is shown in the illustrations on pages 16 and 17 or by connecting to the compressor shaft by means of rigid couplings.



Automatic start and stop from pressure gage control is used on many compressors.
This two-stage, tandem, Chicago Pneumatic Tool compressor is driven by a synchronous motor and controlled by the automatic panel shown at the right. The rotor of the synchronous motor is mounted directly on the crankshaft thus requiring no outboard bearing.

Air compressors of small capacity, notably those of the single-stage type are more commonly belt driven by induction motors. For the sake of space economy the short belt drive with idler pulley is generally employed. An installation of this type is illustrated on page 13. These motors may be either of the squirrel-cage or the wound-rotor type. For continuous - running service the squirrel-cage motor is quite satisfactory, particularly for the smaller machines. For "start and stop" service the wound-rotor motor is to be recommended.

On some types the motor is mounted on the end of the shaft as illustrated on pages 16 and 17. This does away with the need of outboard bearings. The motor may be built into the flywheel as shown at bottom of page 17. This does away not only with the outboard bearings but also with the separate stator bedplate.

A silent chain drive is often used for connecting the air compressor to its motor. Such a drive gives very good economy and flexibility in arrangement of floor space, combined with high efficiency and reliability. In selecting silent chains for air compressor service, it is usual to choose one having a rating of 120 per cent of the motor capacity. A silent chain drive for an air compressor is illustrated on page 15.

Where belt or chain drive is employed there is sometimes an advantage in adjusting the compressor speed and capacity to suit the motor rating. Consider a machine rated at 300 cu. ft. of free air per min. at 240 r.p.m. and requiring 80 hp. If this machine were operated at 225 r.p.m., its capacity would be reduced to 281 cu. ft. per min. and a 75-hp. motor would suffice. On the other hand, if a 100-hp. motor were used, the compressor speed might be increased to, say, 280 r.p.m. (if allowable) and the capacity increased to 350 cu. ft. per min.

Changing the compressor speed by changing the size of motor pulleys may bring the output of the compressor more nearly in line with the demand for air and thereby prevent frequent starting and stopping of the compressor or prevent long periods of operation with the compressor unloaded.

Synchronous motors suitable for direct connection to small air compressors have been recently developed. A 40-hp., 300-r.p.m. synchronous motor driving a 10-in. by 8-in. air compressor is shown in top illustration on page 17. Motors of the type shown are available in sizes down to 20 hp. They offer many of the advantages common to the larger machines, although in lesser degree. For continuous-duty, permanent installations their use is particularly warranted.

Very few large air compressors are driven by direct-current motors. They are sometimes used for medium and small size machines. These installations are generally of the belt drive type, but engine-type, direct-

current motors may be successfully employed where only direct-current power is available. Compound-wound motors are generally preferred, primarily because of their better starting capacity and also because they are more adapted to a load requiring a pulsating torque combined with high inertia.

Effect of Pulsating Torque on Motor Selection

The torque required for driving a reciprocating compressor is irregular, having pulsations due to varying crank effort. A synchronous motor inherently tends to hold constant speed and varies its torque with the slight changes in angular velocity resulting from the varying load torque. This results in a periodic variation in power input. The amount of angular speed variation depends upon the load-torque variation and the inertia of the revolving parts. It is commonly necessary to adjust the flywheel effect for two reasons: first, to prevent the combination of mechanical oscillations due to load and those oscillations due to varying motor torque in a manner to cause resonance and hunting; and second, to limit the extent of periodic current variation.

The Electric Power Club and the American Society of Refrigerating Engineers have adopted the following rule in regard to current variation in synchronous motors driving air and ammonia compressors:

"When the driven load, such as that of reciprocating pumps or compressors, requires a variable torque during each revolution, the combined installation shall have sufficient inertia in its rotating parts to limit the variations in motor armature current to a value not exceeding 66 per cent of full-load current.

"The basis of determining this variation shall be by oscillograph measurement and not by ammeter readings. A line shall be drawn on the oscillogram through the consecutive peaks of the current wave. The variation is the difference between the maximum and minimum ordinates of this envelope. This variation shall not exceed 66 per cent of the maximum value of the rated full-load current of the motor. (The maximum value of the motor armature current is to be assumed as 1.41 times the rated full-load current)."

This rule does not necessarily determine the proper practice in all cases. It is sometimes very difficult to supply sufficient flywheel effect to restrict the current variation within the limits above stated, in which case a greater variation may be permissible. In other cases it may be desirable to restrict the current variation to as low as 25 per cent of rated full-load current.

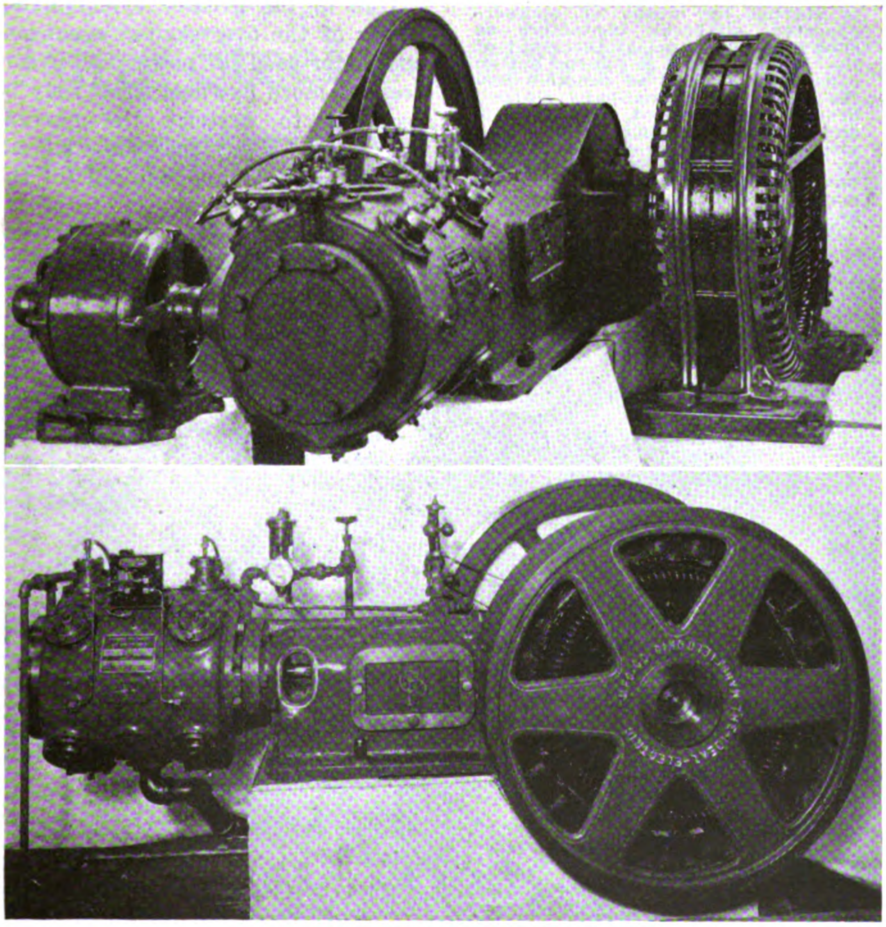
So far as the motor is concerned, a somewhat greater variation than 66 per cent ordinarily has very little effect on performance, reliability, heating, and efficiency of the motor. The matter is largely one involving the effect on the supply system. Where lighting supply is involved a low current variation is desirable. On lines devoted exclusively to power supply, larger variations are not detrimental.

Starting Requirements of an Air Compressor Drive

With two-stage, duplex compressors, it is not ordinarily difficult to supply sufficient flywheel effect to prevent resonance and to restrict the current variation. In some cases the necessary flywheel effect is included in the revolving member of the motor. This practice is open to question if the decrease in effective diameter requires a material increase in weight. Not infrequently it occurs that widely differing values of flywheel effect will meet the requirements, in which case the lowest value may well be used, thereby minimizing both the first cost and the inevitable bearing losses. With straight line compressors it may be more difficult to meet flywheel requirements, due to the greater variation of load torque. For a further discussion of flywheels for synchronous motors see page 451 of the "Principles of Electric Motors & Control" by the writer.

Air compressors, except in the smaller sizes, are ordinarily ar-

Two types of synchronous motors in use on single-stage compressors.
In the top illustration, the rotor of the motor is pressed directly on to a short extension of the crankshaft, thereby eliminating the necessity of an outboard bearing. The stator is mounted on a separate bedplate, which makes a very accessible arrangement. In the bottom illustration is shown a synchronous motor that is built into the flywheel of the compressor. The rotor is on the outside of the stationary element, the fields being attached to the flywheel. The stator winding and core is concentric to the fields and is attached to the compressor frame. This arrangement does away with the necessity of a separate bedplate for the motor, lightens the compressor weight and yet is very accessible for repairs or maintenance. Both compressors shown in these illustrations are single stage and are made by the Chicago Pneumatic Tool Co., New York, N. Y.



ranged to start unloaded. The torque required to start from rest is then 10 to 30 per cent of the full-load torque. A suitable synchronous motor can develop this torque with an input of 150 to 300 per cent of full-load kva., depending upon motor speed and design and the starting voltage. The size of the flywheel materially affects the starting requirements of a compressor drive.

Indirectly it decidedly affects the pull-in torque. As a large flywheel may have too much inertia to be pulled into step from say 95 per cent speed, it may be necessary to reach perhaps 97 or 98 per cent speed by induction motor action. It is much more difficult to obtain a high pull-in torque at 97 per cent speed because the induction-motor torque is nearly proportional to the slip and falls off as synchronism is approached.

Bearing friction influences the starting torque required. The inertia of the compressor affects the pull in torque demanded by making it necessary for the motor to approach more closely to synchronous speed by induction motor action, thereby reducing the speed range through which the flywheel must be accelerated at the instant of pull-in. Compressors with light flywheels require about 15 per cent full-load torque to pull into synchronism under unloaded conditions. Compressors with large flywheels may required 25 to 30 per cent pull-in torques.

Wound-Rotor Motor Best Adapted to Frequent Starting Duty

The synchronous motor is quite satisfactory in starting characteristics for driving air compressors which start only infrequently. It is superior, in many instances, to the squirrel-cage induction motor, since the cage winding of a synchronous motor may be designed with a view to starting requirements only. The wound-rotor induction motor is suitable for "start and stop" service, since the current inrush for a given torque development is low. Synchronous motors with automatic starters are used successfully for this service, however.

Unloading both at starting and stopping is desirable when belt drive is employed, especially with the short belt and idler pulley arrangement. If the compressor is unloaded at stopping it will drift smoothly to rest with the motor. If it is not unloaded, it may jerk the belt and pitch the idler pulley. Some compressors are equipped with a fly-ball device which unloads the compressor when it is running at speeds materially below normal. Some compressors are now equipped with a small electric solenoid which operates small air valves, functioning indirectly to cause unloading. This solenoid is connected so as to be energized by the last operation of the motor control panel, during acceleration, thus causing the compressor to load as the motor attains speed. When power is cut off to stop the compressor, the solenoid drops and immediately causes unloading. In the case of "start and stop" units a cooling water valve is sometimes included in the automatic system to prevent wastage of water when the compressor is idle and vice versa. Where the solenoid unloader is employed it may well be energized from the transformer which supplies the magnetic contactors, but a small increase in the capacity of this transformer may be necessary.

Direct-connected compressors should preferably run "under." A belted compressor may have to run "over" so as to have the slack belt side on top thereby increasing the arc of contact between belt and pulleys.

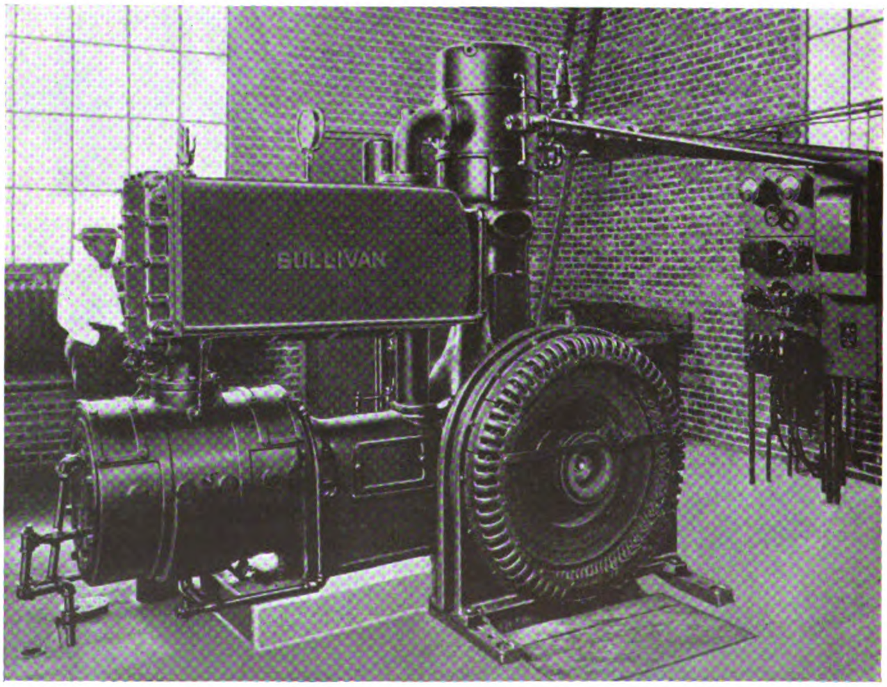
Correcting Power Factor by Air Compressor Motor

In selecting a synchronous motor for driving a compressor, a choice is necessary between the machine which is rated on a unity power factor basis and the machine rated, usually, on an 80 per cent power factor basis, for power factor correction. This point is affected largely by local considerations involving the need of power factor correction and the savings to be made thereby. A unity power factor installation may cause considerable improvement in plant power factor especially in view of the fact that the power factor will be leading when the compressor runs unloaded. A leading power factor motor will not be justified unless sufficient advantage can be realized, through its corrective qualities, to outweigh its higher first cost and lower efficiency. The efficiency at 80 per cent power factor leading will normally be 2 or 3 points below the efficiency that would be obtained at unity power factor.

Due to the greater synchonizing power of the over-excited synchronous motor used for power factor correction, more flywheel effect may be required to restrict the current fluctuation. This may be inherent in the larger frame required for the over-excited machine.

Push-button control offers many advantages for starting synchronous motors.

This angle compound Sullivan Machinery Co., air compressor is driven by a synchronous motor that is started by means of magnet-operated, air-break contactors as shown on the panel at the right of the illustration. A push button causes the control to function and the motor is automatically started, brought up to speed, field applied, and put on the line without any attention from the operator, thereby permitting the use of oilers and unskilled labor for this duty. As may be noticed, this motor requires no outboard bearing.



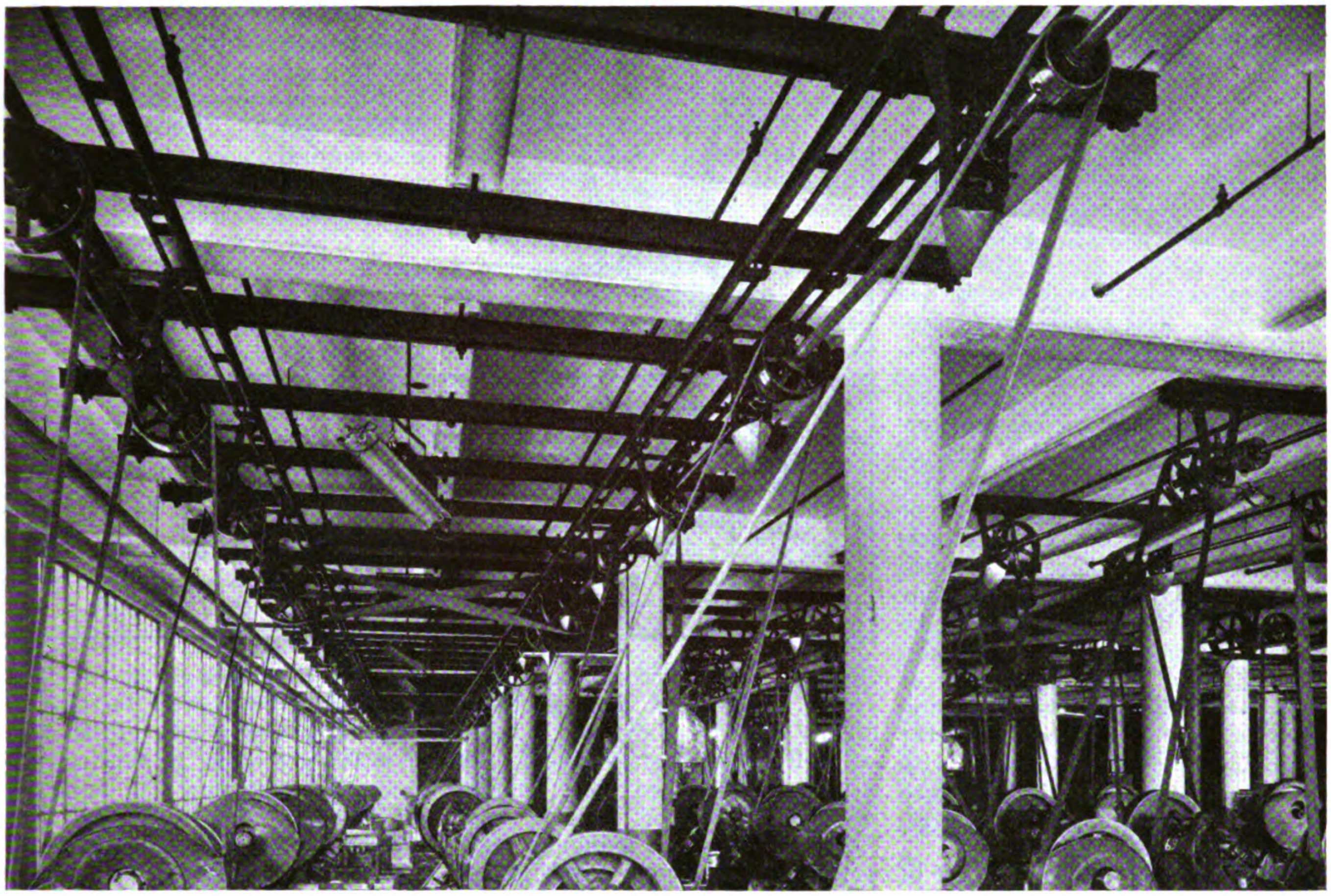


Fig. 1—This lineshaft installation in one of the Chicago plants of the Continental Can Co. is supported by special steel shapes designed for such work.

In this case short inserts were cast in the concrete ceiling beams. Sections of stringers are bolted to these inserts and a longitudinal pair of stringers, which is bolted to these, forms the footings for attaching the hangers. The lineshaft may be easily shifted a few inches or feet by loosening the bolts which hold the two longitudinal stringers and sliding them in either direction. Also, the entire installation may be taken down and re-erected in any part of the building and all of the groundwork re-used without any waste or cutting except when necessary to provide for a change in length of the shaft. The entire building is provided with inserts in the ceiling beams on 4-ft. centers. This is of great importance in the rapid shifting of machinery and departments.

Methods of

Using Steel Forms for Supporting Lineshafting

in mill type, steel and concrete buildings in order to reduce the work of erecting this equipment and to facilitate future changes in layout

By P. L. PRYIBIL

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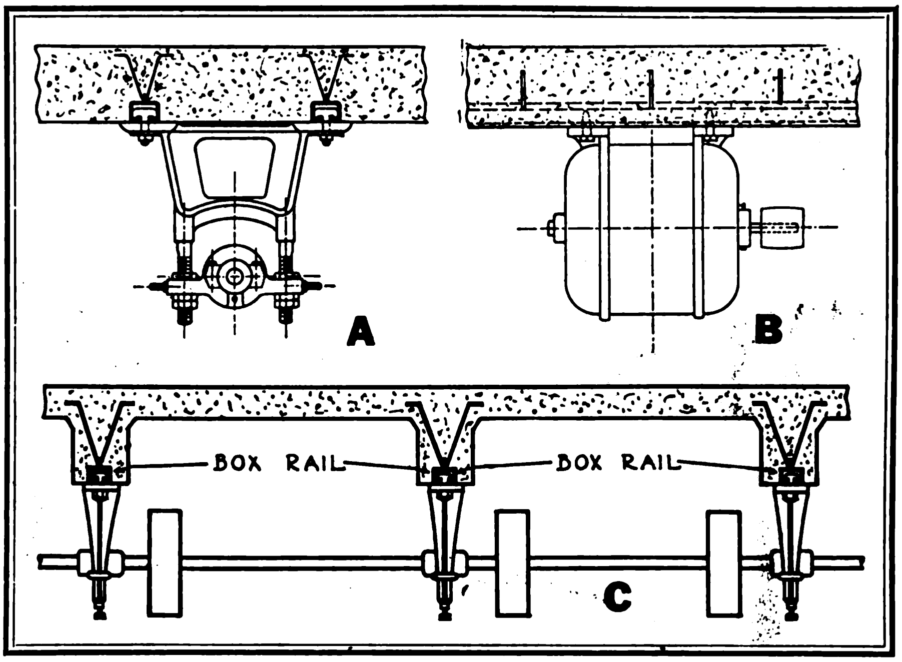
MANY unusual conditions are encountered by the erection superintendent or the millwright when installing lineshafts, especially where the groundwork has to be devised and placed in position. This kind of work as a whole is more diversified than one who is not initiated would imagine and the physical layout and conditions within factory buildings offer very trying problems at times. The competent millwright or erecting engineer who has to solve them is worth all one has to pay him and often more.

For this reason, a discussion of the problems invoked in erecting lineshafts in the different types of industrial buildings in use, with particular attention to the lack of provisions for easy anchorage of mechanical equipment, may be helpful to the readers of INDUSTRIAL ENGINEER, many of whom have to solve problems of this nature. In this article, particular attention is directed toward the remedies which can be provided to partially eliminate these adverse conditions, in so far as the building itself is concerned, or to compensate for them through the use of standardized appliances perfected after many years of experience in erecting lineshafts and supporting various other machinery overhead in industrial plants.

The supporting of lineshafts and countershafts, as well as motors and other power transmission apparatus, in buildings used for manufacturing purposes is nearly always more expensive than the initial estimates indicate and frequently is more difficult than was anticipated when making the plans for the installation. Two of the fundamental reasons for this are the differences in



Figs. 2A, 2B and 2C—Here long box rails are cast in the ceiling, instead of short inserts as in Fig. 1.
These Midwest box rails are of a special shape to take a bolt head and are cast in the concrete ceiling. The equipment or machinery may be supported directly from them as shown in these three illustrations. However, in installations such as *A* and *B* where parallel box rails are cast in the ceiling at the proper distance apart to take a lineshaft hanger or motor footing, there is no opportunity of moving the shafting to one side or other. It is generally much more advisable to set these inserts in the beams, as at *C*, or at fixed centers and attach stringers or cross rails as in Fig. 1.

the styles and types of construction of buildings used for manufacturing purposes, and to the lack of standardized forms or shapes for fabricating the superstructure or groundwork for the direct attachment of lineshaft hangers. The differences in types of buildings apply not only to buildings especially designed for manufacturing but also to converted buildings, such as structures originally built for warehousing or for innumerable other uses, and which are ultimately, with or without alterations, fitted up with machinery and used for manufacturing.

Under the best conditions, that is, where a building is constructed for a particular manufacturing problem or industry and the type of machinery which is to be installed is known, there are still many different types of building construction. One of the most common is the so-called mill construction type; other types are, brick buildings with wood interior, brick and steel buildings, concrete buildings, and some all-steel buildings with steel framework and sheet-metal walls, roofs, and partitions. Nearly all of these are built in multi- as well as single-story designs, except the brick and steel building with saw-tooth or monitor roof. Some multi-story buildings have saw-tooth or monitor roofs on the top floors. Single-story structures are practically always built for owner occupancy, irrespective of what type of construction is used, and so better plans can be made for the installation of the machinery. Multi-story buildings are frequently built for tenant occupancy, to be rented out to one or to a number of concerns for a variety of manufacturing purposes.

The loft buildings in the outskirts or in industrial sections of large cities are typical of the type of building erected for renting to a number of concerns. In buildings of this type it is, of course, impossible to know in advance what kind of equipment will be used by the different tenants, and even if it could be known in the case of the first tenant any provision which might be made for him would seldom be suitable for subsequent tenants in the same space.

Many large firms in this country have made it a practice when building warehouses, particularly in the large cities, to erect a factory-type building and make provisions for using it for manufacturing in the future. Experience has demonstrated that such forethought is necessary, as well as advantageous.

All these different conditions and different types of buildings and the various kinds of equipment to go into them have made it very difficult for the architect, the industrial or plant engineer, and last, but by not least in this instance, the millwright, to work along predetermined lines in providing for the location and support of lineshafting and similar equipment.

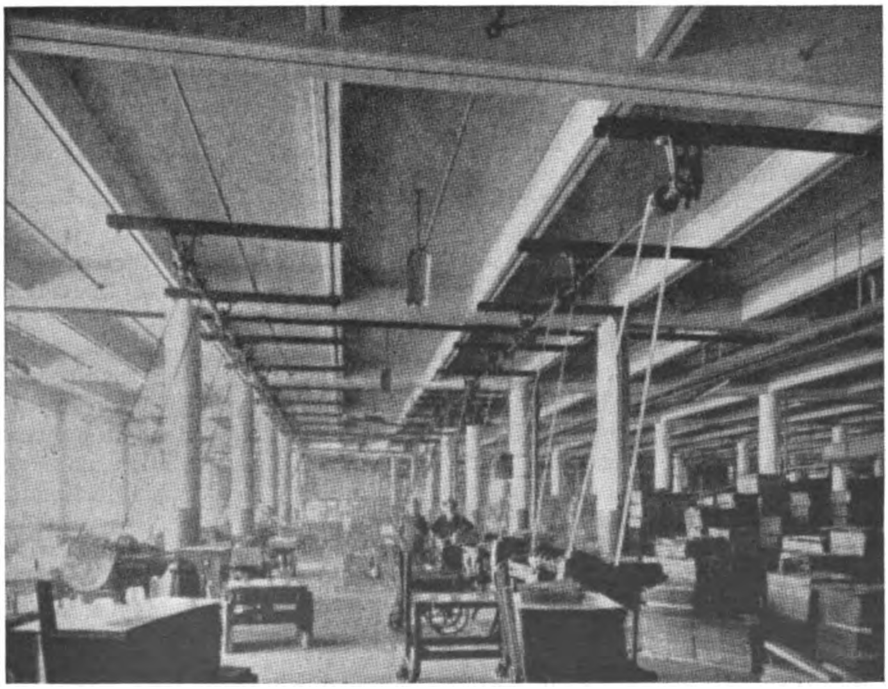


Fig. 3—Box rails are set both longitudinally and crosswise in the ceiling beams of this concrete factory building.
This shows the method of erecting a lineshaft by providing a cross stringer between two parallel rails and attaching the footings of the hangers to these. If the lineshaft had been extended crosswise in this room the construction shown in Fig. 2C, could have been used.

Until recent years wood has been a popular material for making supports in the form of footings, stringers and for the framework and body of superstructures. In fact, in some parts of the country, timber has been used almost exclusively. Wood is adaptable for such purposes, but only to a limited degree, and it is not flexible nor interchangeable. It can be cut to desired lengths and widths, it can be notched and drilled to receive bolts and lagscrews, but this is always a cut-and-measure proposition, involving a certain amount of carpenter and millwright work. Although, when finished, the component parts may resolve themselves into a more or less practical and harmonious whole, the resultant truss or framework will be suited only to the particular position and installation for which it was fabricated.

Rarely can the same layout be used to suit another condition; of course, the material itself can be recut and reformed and some of it used over again, but the framework for intermediate supports usually has to be redesigned for each particular case. However, in spite of its main advantage, which is that it is comparatively easy to work, wood has a very distinct disadvantage in its susceptibility to changes in temperature and its inherent tendency to dry out which causes it to shrink, warp and twist constantly and sometimes for many years after it has been installed.

This characteristic is the chief cause of trouble where wood is used to support overhead equipment and is responsible for much of the consequent misalignment of lineshafting and motors, which causes belting troubles and bearing replacements all along the line down to the last production or operating unit. Wood which is suitable for this groundwork for shafting, is comparatively cheap, especially in certain geographical locations, but the troubles so frequently caused by its shrinking often in the end offset the apparent saving in first cost.

When heavy loads and long spans have to be contended with, as for instance in brick and steel buildings where the bottom chords of the roof trusses are from 18 ft. to 24 ft. from center to center, timbers of large cross-section have to be used; such stringers are often 8-in. by 12-in., or even 10-in. by 14-in., and impose a serious additional load upon the roof trusses. It is because of the live load and the impact to which the lineshaft is subjected, as well as to minimize the deflection, that such heavy timbers have to be used. Because of their weight these members are much more costly than structural or other metal stringers and they cost more to handle as they require expensive rigging to erect.

In many cases, as outlined above, wooden stringers are not always dependable even after they are installed. The millwright is well aware of all these deficiencies, but is not always in a position to dictate the remedies. On a heavy headshaft hanger or post hanger he will often put a square steel washer between the hanger foot and the wood stringer. By this means he is endeavoring to secure a firm, even base for his hanger foot to offset the effects of vibration and thereby maintain permanent alignment of his lineshaft and of all the other driven units which depend upon proper alignment for their satisfactory functioning. However, the use of wood for such purposes, in a steel or concrete building, or in any kind of fireproof building, is decidedly inconsistent.

Standard structural steel members and shapes have been used very satisfactorily for constructing groundwork and as stringers for lineshafting. These are lighter than wood for large spans and they are susceptible to much greater flexibility of arrangement. However, structural steel is hard to cut, drill, and form in the field. Furthermore, standard structural steel shapes are not primarily designed for this purpose and as a natural consequence special fixtures become necessary and channels or I-beams have to be used, which in many instances, are heavier than necessary. This extra weight is an additional expense, not only because it is paid for by the pound but also because of the extra labor in handling the heavier weights on the job. The cost of cartage and railroad transportation is also on a weight basis. In addition, as when heavy wooden stringers are used, there is the extra deadweight load on the ceiling or roof trusses.

Cutting, punching and the general fabrication of standard steel shapes is comparatively easy in steel mills or fabricating shops, but in order to have this work done there and to insure its fitting properly and matching up to the members to

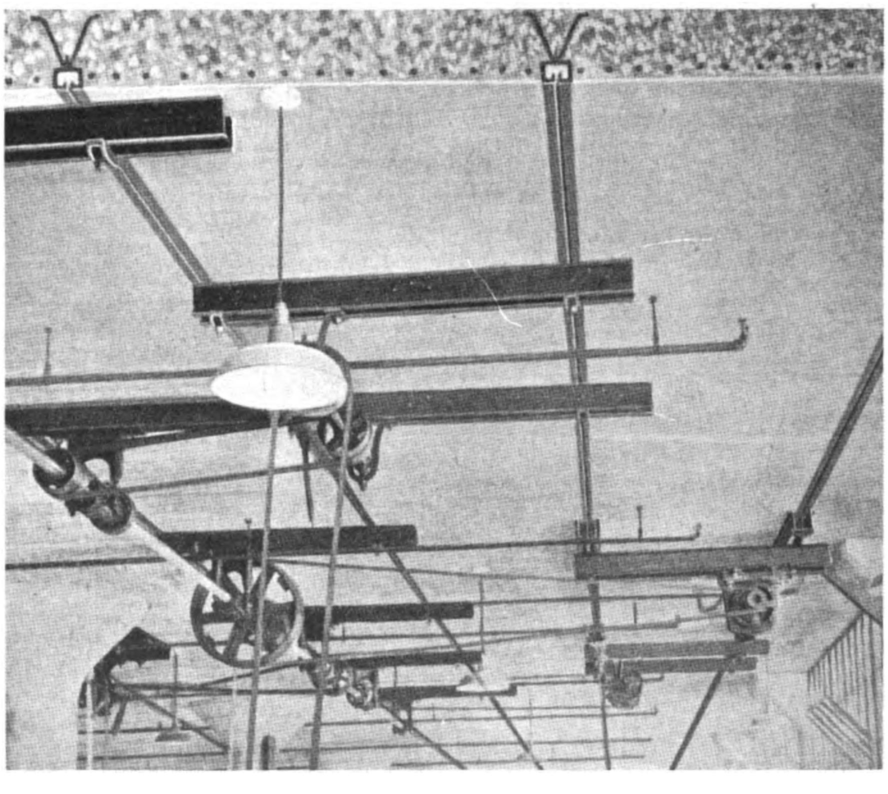


Fig. 4—Part of a lineshaft installation in the Saco-Lowell Shops, Boston, Mass.

This photograph was retouched at the top to show the construction of the box rail in the ceiling and its reinforcing. These box rails are set in the concrete on fixed centers. The method of attaching the footings and groundwork for not only the lineshaft but additional countershafts and motor mountings is also shown.

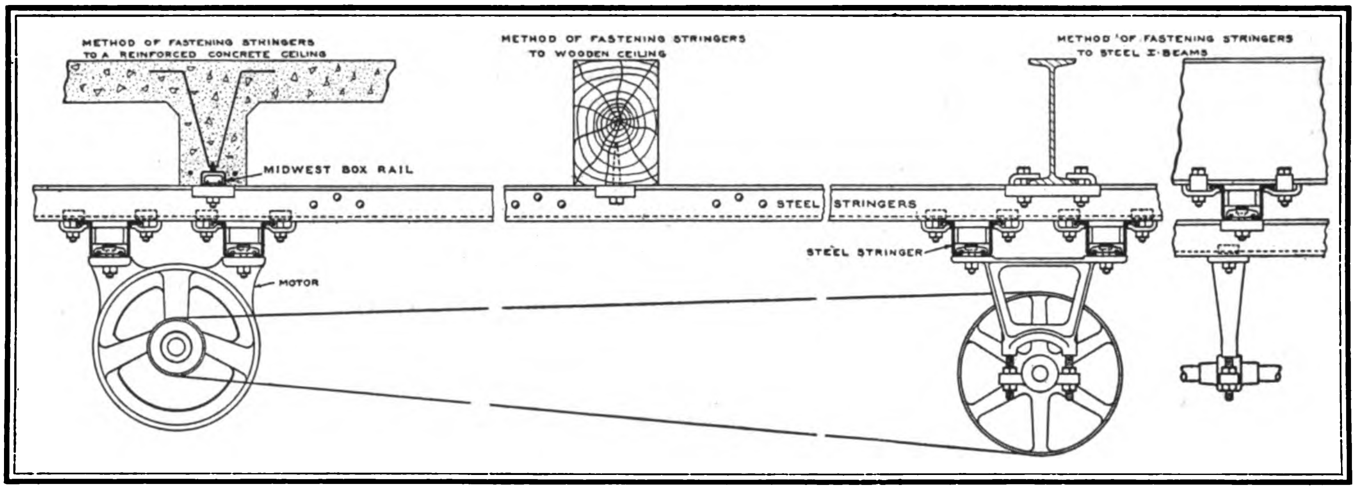


Fig. 5—This composite drawing shows three methods of construction for supporting lineshafts.

The method of fastening stringers to a reinforced concrete ceiling with the box rail cast in the beam, the method of fastening to wooden beam ceilings, and also to steel I-beams are shown in this drawing. These steel stringers are especially designed for this work and are made in standard sizes for different loading. The stringers and shafting are erected and fastened together with standard attachments.

which it has to be bolted in the building all dimensions and specifications must be exact. This requires a lot of work in the drafting room and in many cases cannot be started with safety until the building, or at least the steel framework, is finished. The new factory may be miles from a machine shop or even a hardware store, and when millwrights at a wage rate of anywhere from $9 to $14 a day have to cut through steel I-beams with a hand hacksaw or cold chisel, or support a heavy electric or air drill on a precarious scaffold, sometimes in a cold, damp building, the progress of the work is likely to be slow; meanwhile helpers and others often stand around and wait. If the power or air supply for the drill were always available, everybody would be happy; more often in the case of a new building, there is no current or air available either in the building or contiguous to it, and so the slow, old-fashioned method has to be pursued while somebody pays the modern up-to-date high rate of wages.

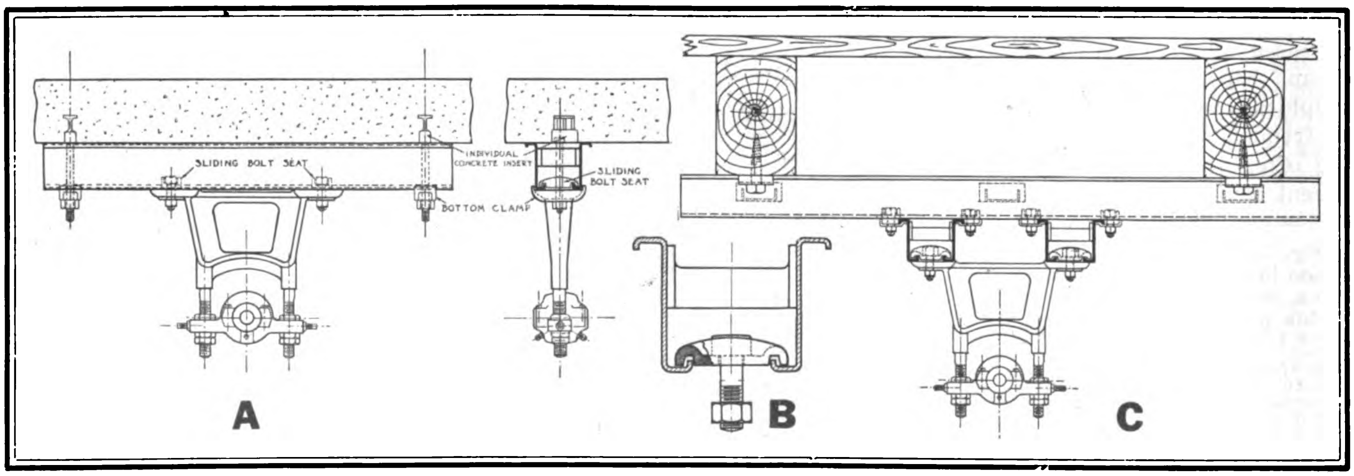
In arranging for the location of power transmission lines and equipment, the customer will often place his pencil on the blueprint before him, and say, "We'll just put our lineshaft here." It is so easily and quickly said, but what a deal of work and even ingenuity are sometimes involved in planning, measuring up for it, and in its installation. All things considered, the installation of a lineshaft, which is really the prime mover, generally proves to be a man-sized job, especially under the old methods.

A good, substantial, wooden building with heavy beams and girders, and with broad trusses and columns of large sectional area, gives dependable supports for lineshaft hangers and largely simplifies the work of the millwright in erecting the lineshaft. The troubles incidental to drying out come later.

In concrete buildings the individual concrete insert, which is set in place in the form and the concrete poured around it, is a great help for supporting equipment. These inserts are usually dependable for ordinary lineshaft drives using shafting up to 1 15/16 in. in diameter. Such inserts are generally placed on 4-ft. centers, running in both directions. This saves much work in drilling holes for anchors

Figs. 6A, 6B and 6C—These show two other types of construction and also a cross-section of this special stringer.

In *A* is shown the method of installation where the hangers are supported midway between and on a line with ceiling inserts. As these inserts are usually on a 4-ft. center spacing and lineshaft hangers are commonly spaced 8-ft. this construction is usually possible. *C* shows the use of a short stringer between two wooden ceiling beams and the longer longitudinal stringers which give rigidity to the construction and to which the hangers are attached. A cross-section of the stringer, together with the detail of sliding bolt, is shown in *B*. This consists of two special steel shapes, somewhat on the order of the letter Z, which are fastened together by steel cross braces placed at regular intervals. Standard bolts and attachments permit these to be clamped easily to each other or to any other standard or special shape.



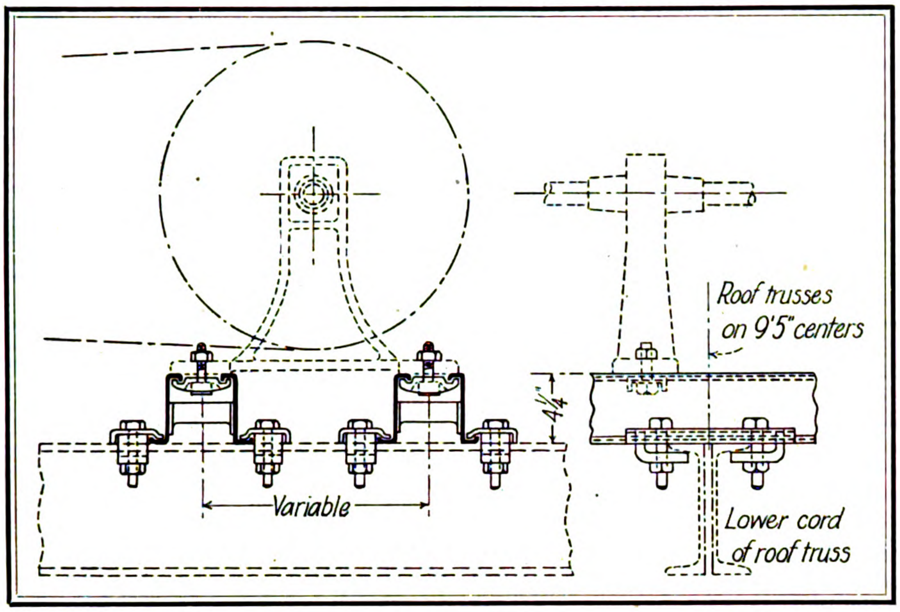


Fig. 7—This sketch shows how a standard construction can be used for a special purpose.

In this case it was necessary to attach a lineshaft to the top of a ceiling beam. To do this the same standard type of construction was used as would have been used if the attachment had been made on the bottom of the beam or if it had been made along an inside wall. This can be easily seen by turning the drawing over or revolving it 90 deg.

and patching them up again after the equipment is installed. Installations using this type of construction are shown as Figs. 1 and 9. Wood or steel stringers are suspended from two or more of these individual concrete inserts and lineshaft hangers or other overhead equipment attached to the stringers or footing pieces.

By referring to these two illustrations it is easily seen how a lineshaft can be placed anywhere between two lines of inserts by shifting the hangers without changing the groundwork. To move a line of shafting the entire construction can be taken down and erected again in the new location by attaching it to different lines of inserts. This is of especial importance in manufacturing institutions because a change in product or a wide variation in the quantity of production may require an extensive shifting of machine and lineshaft arrangement. This is more easily done if it is not necessary to again drill holes in the ceiling and refabricate the groundwork. With special steel stringers and inserts the shafts can be taken down and erected in the new location and frequently the same steel parts are reused in the new groundwork. This ability to reuse the material without additional fabrication goes far toward overcoming any difference in first cost of such material when compared to wood.

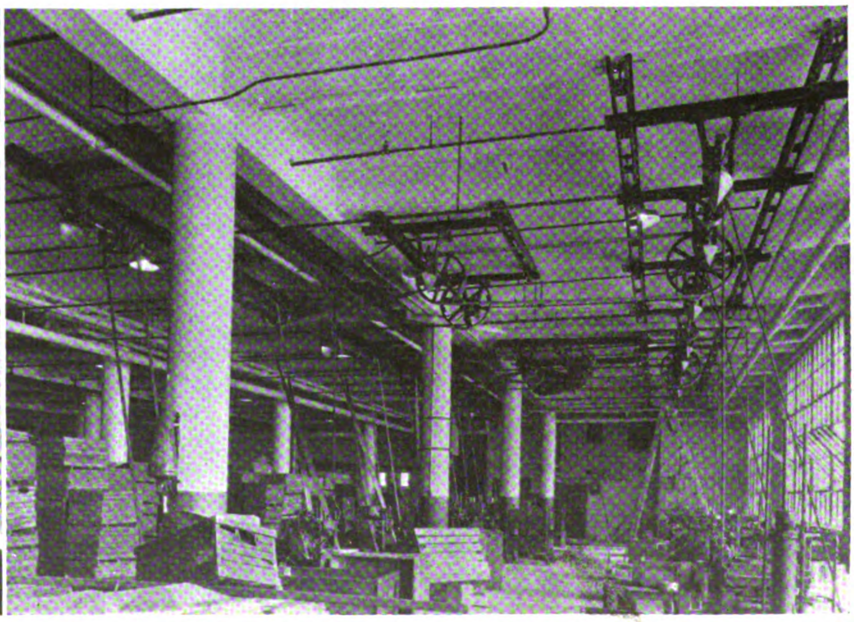
A much better way to provide for light, as well as heavy shafting, in a concrete building is to use the long, continuous type of box rail insert. These inserts are attached to the wooden forms, before the concrete is poured, in the same manner as are the small individual inserts, but as they come in lengths of 5 to 20 ft., and may be obtained longer if necessary, they are much easier to handle, are less trouble to place, cannot be knocked over by the concrete when it is poured and, on account of their long length, insure proper alignment. When the concrete forms or molds are removed, a surface slot of steel is left in the concrete slab, the beams or the girders.

Figs. 2 to 5, inclusive, show diagrams of box rails as they were placed in the ceiling of two large plants, together with the method of attaching lineshafting and other power transmission appliances to them. As will be noted from these illustrations, the hollow steel box rail is cast in place and the surface slot which is flush with the concrete,

* * * *

Figs. 8 and 9—Here is a neat-appearing method of mounting motors and lineshafts.

Fig. 8, at the left, shows the method of mounting 15 10-hp. motors in a line on the ceiling. The longitudinal stringers, that carry the short cross-footings to which the motors are attached, are clamped to the I-beam ceiling supports. This gives a simple construction which can be easily shifted to change the position of the motor or its arrangement. Fig. 9, right, shows another section of the installation in one of the Chicago plants of the Continental Can Co. Here inserts were cast in the ceiling beam (some of these can be seen in the first ceiling beam) for supporting the lineshafting.



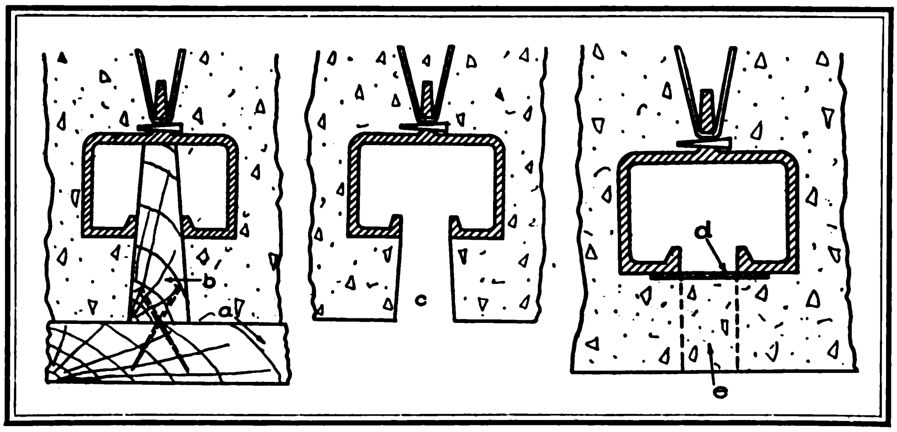


Fig. 11—Box rails may be set either flush with the beam or slab or imbedded 1½ in. in the concrete.
For simple imbedded rails the illustration at the left shows how the box rail is protected from filling during the pouring of the concrete. After the wooden form is removed the arrangement is as shown in the center illustration. For complete fire protection and where it is desirable to protect the box rails from fumes, the construction may be as shown at the right. In this case the box rail is supported away from the bottom of the form and the continuous slot in the bottom flange of the box rail is covered with a strip of roofing felt or felt paper, as shown at *d*, stuck on with roofing pitch or held on by wire. To use this box rail, holes may be cut or drilled into the concrete at the point where it is desired to place the bolt for attaching stringers or other equipment. After the bolts are placed and adjusted in the correct position the openings are filled with cement grout and thus sealed.

is immediately available for the attachment of the groundwork for lineshaft or other hangers. The box rail can be just as easily installed under or below the surface of the concrete, Fig. 11, if desired, so that the slot is still available without the rail being in evidence.

The installation of box rails does not weaken the concrete slab or member in any way but on the contrary acts as a reinforcing rod; as the box rail has a greater cross-sectional area than a bar 1 in. square, for instance, considerable additional reinforcement is provided. This continuous type of insert can be, and frequently is, laid horizontally or vertically in the walls as well as in the ceiling of concrete structures. Also, some large automobile plants have used them in the concrete floors for holding motors and for floor stands for lineshafts as well as for machines and other equipment. Incidentally the box rails are used in brick work as well as in concrete.

In developing the Midwest universal system for supporting overhead mechanical equipment it became increasingly obvious as the work progressed that it would be as necessary to provide for changes in equipment location as to work out the "where and how" of originally installing it. Complete changes in production processes and other radical departures from the regular order of work occur in the plant occasionally on account of taking on a different product. The resultant modifications in the nature of the operations may make it necessary to equip, at least in some departments, with entirely different kinds of production units. These and other difficulties were taken into account in the development of special steel stringers.

These stringers can be used for supporting any kind of lineshaft in any kind of factory building. A few interchangeable clips provide for attaching the stringers to all types of structural steel members, and to wood or concrete ceilings or side walls where individual inserts or box rails have been provided. No drilling of holes in the stringers is necessary; they are merely clipped into place with standard square- or hexagonal-head bolts. Special tools or fixtures are not necessary; an ordinary wrench is used for tightening the nuts on the bolts.

If changes become necessary for alignment, repositioning or moving the stringer to a different location the nuts are loosened and the stringers tapped over or completely shifted several feet. By means of the sliding bolt seat the shaft hangers or other equipment can be moved the full length of the stringer without encountering any obstructions. Advantage can be taken of this feature to facilitate tightening slack belts from lineshafts to countershafts and so eliminating the necessity for cutting and relacing.

Fig. 5 is a composite diagram showing how standard steel stringers may be attached to wood, concrete and steel construction buildings. The clips and clamps used are of standard construction and may be purchased with the stringer. Figs. 3, 4, 6*A* and 9, show applications of steel stringers on concrete flat slab and on concrete beam and girder buildings. When the stringers

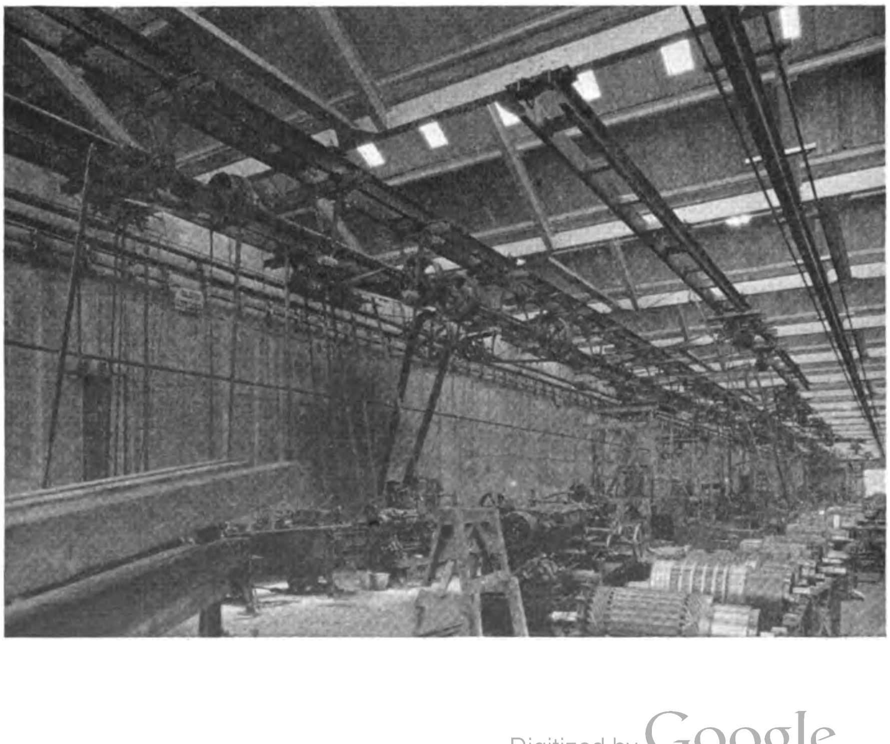


Fig. 10—Standard 10-in. channels in pairs are used as stringers.
The illustration shows a section of the repair and maintenance shops of the Interborough Rapid Transit Co., New York City. Standard 10-in. channels, braced together in pairs, are clipped to the ceiling beams and are used as stringers for supporting the 300-ft. lineshaft. The feet of the hangers are attached to short cross-stringers as shown. This entire structure was fabricated in sections and erected by bolting together and to the ceiling I-beams with standard bolts, clips and clamps and can be moved and re-erected easily.

are used on wooden beams or trusses, Fig. 6*C*, lagscrews are used.

Steel stringers can be easily clipped together at right angles to each other, as shown in Figs. 5 and 6*C*. This adds greatly to the flexibility of the system and is especially handy where top stringers are used as groundwork and where odd-sized hangers are used, or where motors of different sizes are installed.

To take advantage of all available headroom a lineshaft is sometimes placed on top instead of on the bottom of the roof beams, as shown in Fig. 7. This illustration is from a drawing of an actual installation. If the drawing is turned upside down, which would be the same as mounting the equipment on the bottom of the stringer, the relation of the stringers and all fastening parts would be the same for the reversed installation. If the drawing or installation is turned 90 deg. the relation of all parts would still be the same; such an installation as this occurs where the lineshaft is erected on columns down the center or along the side wall of the building.

Part of an installation of electric motors mounted overhead on the steel ceiling beams in one of the large yarn mills of Wm. Crabtree & Sons, Newburgh, N. Y., is shown in Fig. 8. The use of steel stringers makes a neat-appearing installation. Steel stringers like these are used for all lineshafting construction throughout this Company's plants.

The method of supporting lineshafts at the plants of the Continental Can Co., Chicago, Ill., is shown in Figs. 1 and 9. Box rails and steel stringers are also used in these plants for supporting conveyor systems on a large scale, Fig. 14.

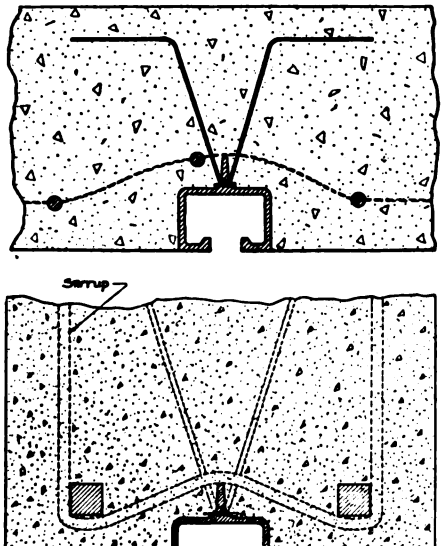


Fig. 13—These diagrams show the method of setting the box rail around the reinforcing in concrete slab and beam construction.

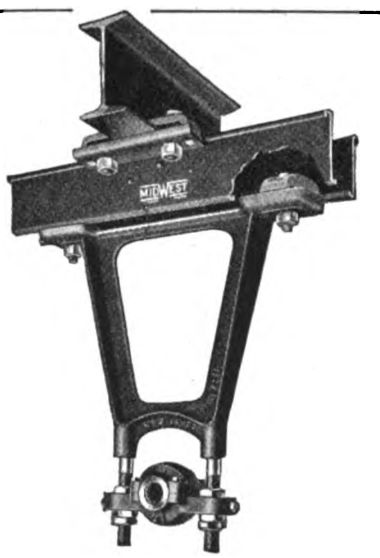


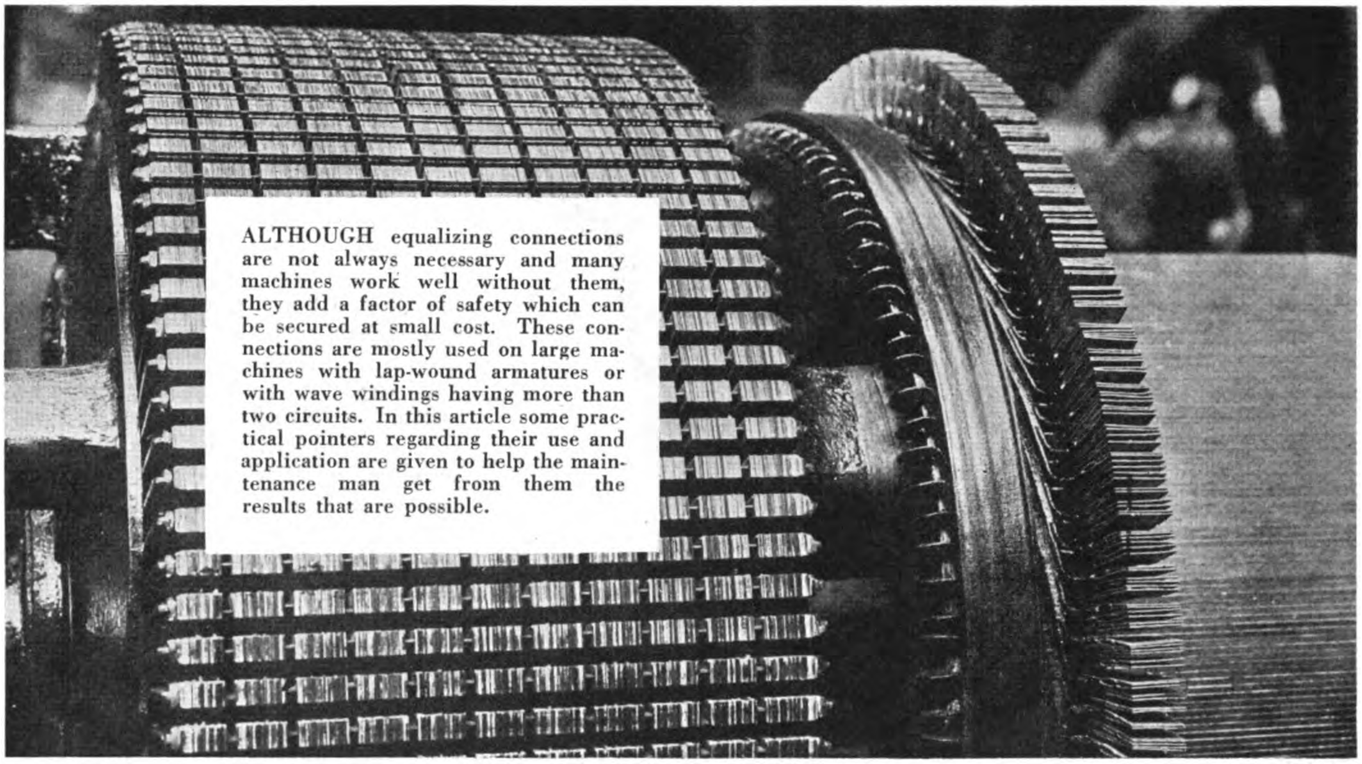
Fig. 12—One method of attaching a stringer to a standard I-beam. The hangers are then attached to the stringer.

Fig. 10 shows an installation of steel stringers in the maintenance and repair shops of the Interborough Rapid Transit Co., which operates the subway system in New York City. Railroad repair shops require, mostly, heavy-duty machine tools of greatly diversified character. Work is on a close schedule and usually on a 24-hr. basis. Here the bottom of the roof beams is 18 ft. above the floor. There is an exceptionally long span between the beams. Large diameter lineshafts 300 ft. long, which are paralleled by shorter shafts and lines of jack- and countershafts as shown in this illustration, are practically duplicated on the right of the telpher monorail track extending overhead down the center of this section of the shops. In this construction commercial 10-in. channels are used for the stringers and special steel footings for the hangers are fastened by special attachments. The channels were fabricated and riveted in sections at the steel works and attached to the frame of the building by clips. It is interesting to note that in this entire installation, Fig. 10, the groundwork with every piece of apparatus attached to it, was completely erected without the drilling of a single hole while it was being erected. Also, this installation could be re-erected in any other part of these shops, covering several acres, without refabrication. Flexibility of arrangement was paramount in this installation.

To the man responsible for the supervision of the installation of lineshafts perhaps one of the most important points to consider is the necessity of planning ahead on how this can be done on future additions to the plant, particularly if the plant is of concrete construction. It is futile to attempt to determine where the shaft is to be and to set two rows of box rails or a few inserts and expect to fasten the hangers to them. In all likelihood by the time the plant is built the plans will have changed so that the inserts will be far enough out of the necessary position so that they cannot be used. The only practical plan is to set box rails or inserts in the concrete on standard centers or at specified distances apart so that they may be used wherever it is desired to put the shaft in the first place or to remount it when necessary to move it. One Chicago plant for instance has inserts cast in the ceiling on 4-ft. centers each way. It is a very simple matter to erect or shift a lineshaft and the same material is used over again on the new job without any cutting or fitting.

Some of the methods of inserting box rails in the ceiling are shown in Figs. 11 and 13 and a more detailed description of their use given in the caption accompanying the illustrations. The concrete is poured around the box rail and it becomes a part of the reinforcement of the building. Box rails are also set in the walls to carry radiators, pipe and conduit lines, and support motors or machinery mounted on the walls.

Fig. 14—Conveyors are also supported from the box rails and ceiling inserts.



ALTHOUGH equalizing connections are not always necessary and many machines work well without them, they add a factor of safety which can be secured at small cost. These connections are mostly used on large machines with lap-wound armatures or with wave windings having more than two circuits. In this article some practical pointers regarding their use and application are given to help the maintenance man get from them the results that are possible.

Fig. 1—This illustration shows a common type of cross connection consisting of one-turn open strap copper coils which are placed in two layers at rear of commutator.

Some of the reasons for using

Cross or Equalizer Connections on Lap Windings

together with practical rules governing the application of these connections, and a description of the different ways in which they can be arranged

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IN THIS article a brief explanation of the reasons for employing equalizer or cross connections on lap windings is given, with the necessary rules and methods for making use of such connections so that the shop man will know how to proceed to check up a rewinding job on which they are used.

In a motor or generator, the armature is concentric with the field poles; that is, the air gap is equal under each pole. Also the magnetic density is supposed to be the same under each pole. This may not always be the case, due to the inequality of materials used, and the armature may be out of alignment due to bearing wear or other causes.

This will allow one side of the armature to rotate in a stronger field and without cross connections, the above conditions will cause a current to flow between brushes of like polarity. In other words a circulating current will be set up in the windings and this current may increase to such magnitude as to damage the machine.

These circulating currents have the same effect as though two generators were mounted on a common shaft, and the potential of one raised above that of the other. Then, the machine having the higher voltage will act as a generator, while the other will act as a motor. This will cause dangerous sparking and burning of the brushes and also cause heating, thus decreasing the capacity.

There is also the possibility of the winding being damaged by these currents. However, when points of equal potential are connected together, the currents that flow through these cross connections in cases where the armature gets out of alignment are alternating in character, and are either leading or lagging in reference to their respective electromotive force. These cross connections direct the flow of the current so that they magnetize or demagnetize the field and automatically produce a balance.

This balancing of the magnetic circuits by cross or equalizer connections is also helpful in preventing any unbalanced magnetic side pull on the armature, should it get out of center due to bearing wear. This side pull on large, lap-wound machines that are off center only a small fraction of an inch, may amount to 5 or 6 tons and cause heating, rapid wear of bearings and excessive stresses on the shaft. This trouble cannot occur on cross-connected machines, for the reasons explained above.

Cross connections are not used on wave windings since the series of coils tends to automatically balance

or average any lack of uniformity between different poles.

Cross connections should connect together points on the armature that are of equal potential and like polarity; that is points 180 deg. apart on four-pole machines, 120 deg. apart on six poles, 90 deg. apart on eight poles, or 360 deg. divided by the number of pairs of poles for any number of poles. From the above it follows that there will be two equal potential points on a four-pole winding, three on a six-pole, four on an eight-pole, etc., or that there will be as many points as pairs of poles, and that the method used to connect these points must form a separate circuit or ring. There can be as many of these circuits as there are bars, but the most common method is to provide about 30 per cent equalization; that is, one-third as many rings as bars, the cross-section of the cross connection being 50 per cent of the armature conductor cross-section.

These cross connections are arranged on an armature in a number of different ways. Fig. 1 shows one common method, which consists of a two-layer, one-turn open strap copper coil winding, placed at the rear of the commutator.

As a general rule three or more straps are tapped together to form a winding unit and with this method 100 or 50 per cent equalization is generally used. The spacing is 1-and-2 or 1-and-3. With this type of connection each bar that is tapped has two connections to it; that is, a top and bottom equalizer lead. The distance in bars between top and bottom leads of any one cross connection is equal to the total number of bars divided by the pairs of poles. The disadvantage of this type of cross connections is that they are under the winding leads and hard to get at when it becomes necessary to make repairs.

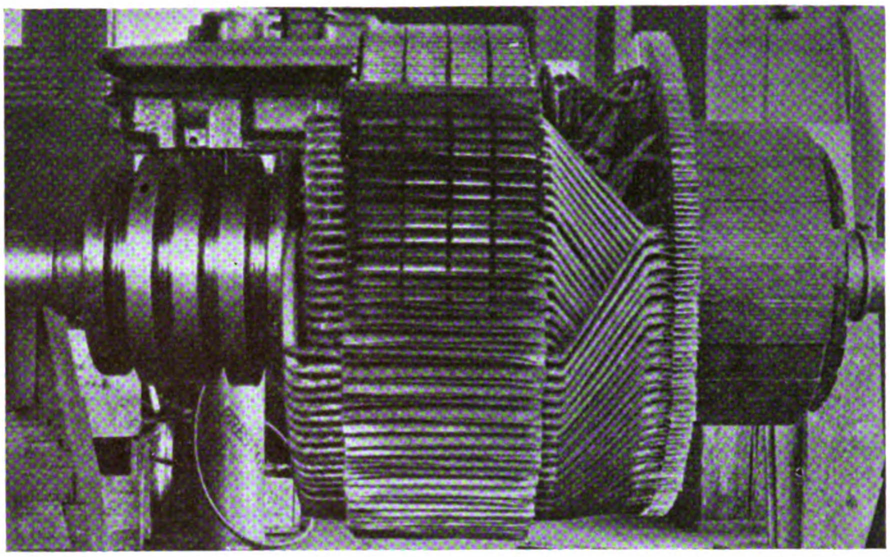


Fig 3—Here is another type of cross connection consisting of a number of rings of flexible cable tapped at proper points and with flexible leads brought out to the commutator bar necks.

Another type of cross connection placed at the rear of the commutator is shown in Fig. 2. This consists of S-shaped conductors nested together to form a two-layer winding, the equalizer bars having two taps made to it as shown in Fig. 2. The data for Fig. 2 are, 41 cross connections, 126 bars, 6 poles; the connector pitch is $126 \div 3 = 42$, or 1-and-43. The spacing is $126 \div 42 = 3$, or 1-and-4.

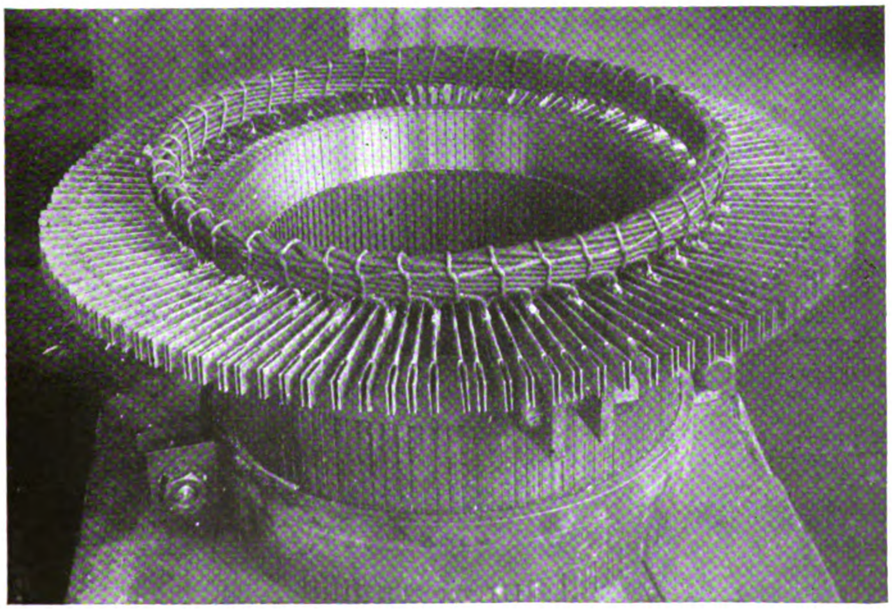


Fig. 2—This type of cross connection consists of S-shaped conductors nested together to form a two-layer winding with equalizer bars having two taps made to it.

Another type of cross connection used behind the commutator is shown in Fig. 3. This consists of a number of rings of flexible cable tapped at the proper points and flexible leads brought out to the commutator bar necks, as shown.

Another style of equalizer connection consists of a number of complete rings at the rear of the armature with taps taken off each ring at equidistant points. This type is shown in Fig. 4. The winding shown has seven rings, with seven taps to each ring, as the armature belongs to a 14-pole machine. There are $7 \times 7 = 49$ taps in all.

A type of equalizer connection used in small machines is shown in Fig. 5. This consists of a number of small rings with taps of thin strip copper. Each ring is insulated and assembled, one inside the other, and the whole bound together and connected to the winding when the latter is in place.

The latest type of cross connector is shown in Fig. 6, *A* and *B*. This consists of a number of S-shaped conductors, nested together to form a two-layer winding but placed at the rear of the winding where it is easily accessible. In Fig. 6*A* note the heavy supporting rings, and the method of tying the connectors to this ring. With this type a special loop is made at the rear end of the tap coil and this loop is drilled to receive one or two rivets. The connectors are fastened with rivets and then soldered, making a good sub-

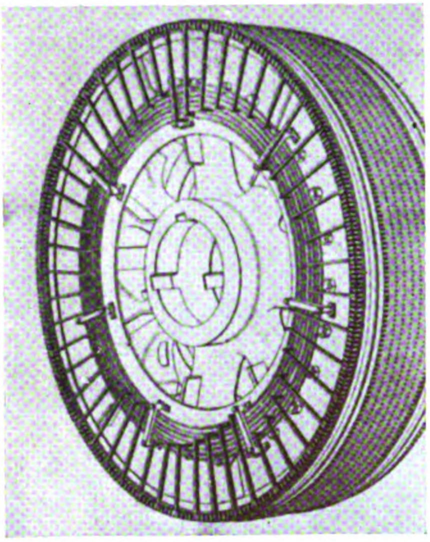


Fig. 4—In this arrangement of equalizer connections there are a number of complete rings at the back of the armature with taps taken off each ring at points spaced equal distances apart.

stantial construction. In Fig. 7 are shown equalizer connectors that form a two-layer winding at the rear, the connectors being involute-shaped.

In what follows some winding rules are given for applying equalizer or cross connectors.

Consider the ring type first, and refer to Figs. 3, 4 and 5. As stated before, points on the commutator or winding that are (No. bars $\div$ pairs of poles) apart should be connected together. It follows then that the least number or rings will be equal to one ring for each pair of poles; that is, there will be two rings for a four-pole machine, three for a six-pole, four for an eight-pole, etc., and the least number of taps per ring will also be equal to one-half the total number of poles. The maximum number of rings would be equal to the number of bars or single coils divided by the number of poles.

The number of rings times the number of taps per ring $(R \times T)$ determines the spacing. The number of bars $\div (R \times T)$ must be a whole number for the number of rings selected to wind.

For example, consider a 14-pole machine with 224 bars, 112 slots, 2 coils per cell. Then the pairs of poles equal 7, the least number of rings also equals 7, and the taps per ring equal 7. The total number of taps $(R \times T)$ equals 7×7, or 49, and the spacing is $224 \div 49 = 4\ 4/7$ which gives an unequal spacing that will not wind. Next, find the least common multiple of 224 using the number of taps per ring as the first factor, or $224 \div 7 = 32$. By dividing this answer by the largest possible divisor, we find the smallest number of rings that will wind, or $32 \div 8 = 4$. Trying eight rings,

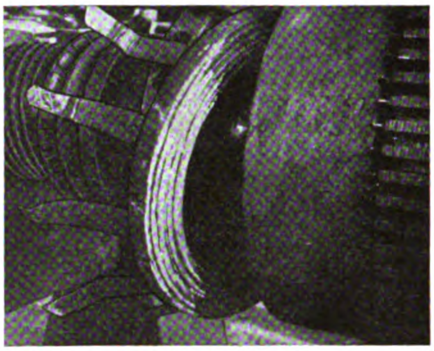


Fig. 5—In small machines equalizer connections are used that consist of a number of small rings with taps of thin strip copper.
Each ring is insulated and assembled one inside the other and the whole group bound together and connected to the winding when the latter is in place.

Fig. 7—This photograph shows an equalizer connection that forms a two-layer winding at the rear, the connectors being involute-shaped.

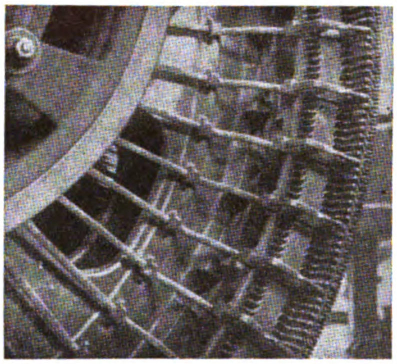
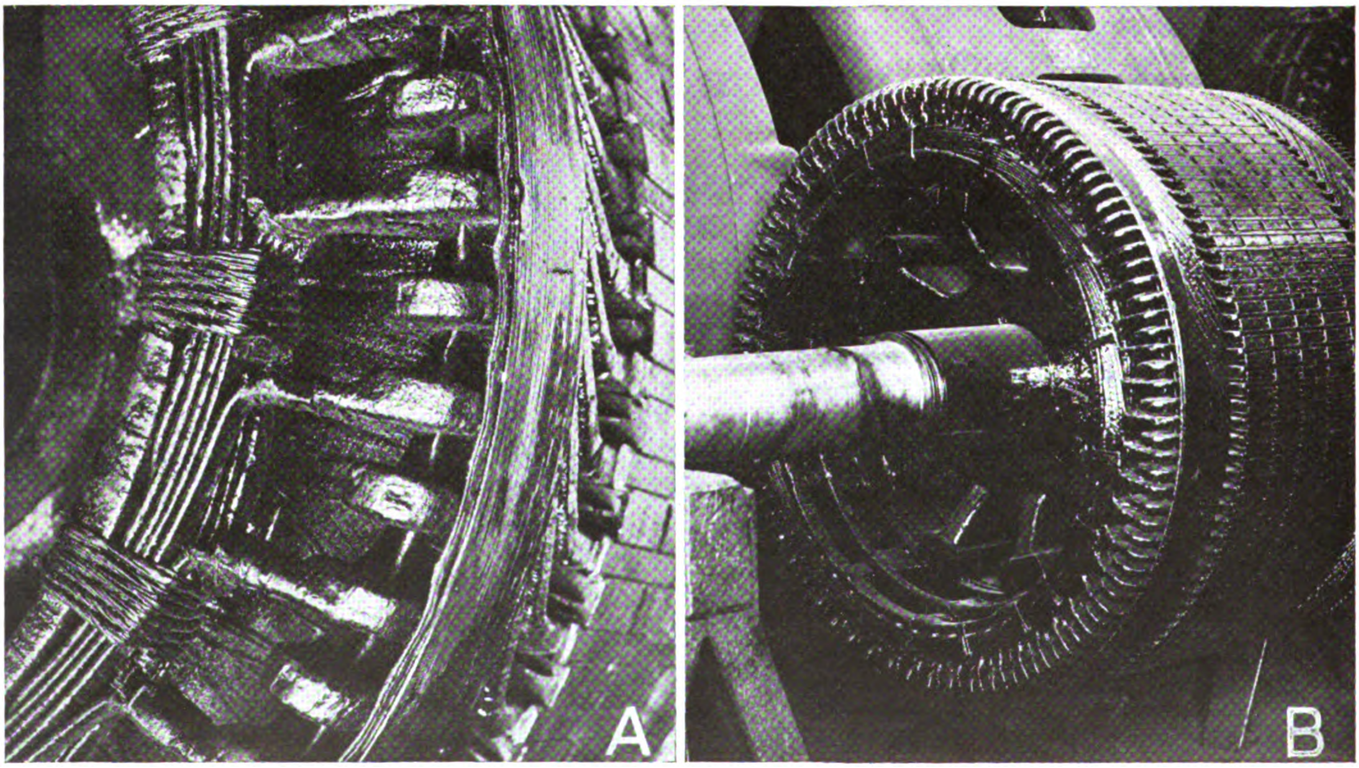


Fig. 6—This is a modern type of cross connection.
It consists of a number of S-shaped conductors nested together to form a two-layer winding and placed at the rear of the winding. In *A* note the heavy supporting rings and the method of tying the connectors to the rings.



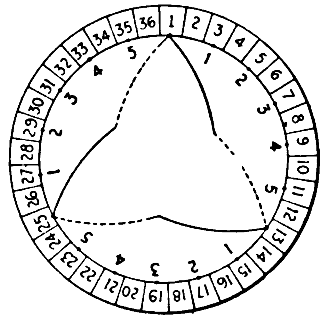


Fig. 8—This diagram shows a way of determining the number of connectors that can be used with any winding by proper spacing.

Three equalizers are shown for a two-layer type of cross connection, these equalizers being connected to bars *1*, *13* and *25*.

$(R \times T)$ equals $8 \times 7 = 56$, and $224 \div 56 = 4$, or the spacing will be 1-and-5. The pitch between taps on each ring will be $224 \div 7 = 32$.

We can now lay out the ring data as follows: Ring No. 1 will connect with bars *1, 33, 65, 97, 129, 161, 193*, or starting with bar *1*, we add the top pitch until a number of points equal to the number of pairs of poles per ring are tabulated. To check each ring add one more pole pair pitch, which should give the bar number that the series of ring taps started on, or 193 plus 32 equals 225 or bar *1*. The spacing is 4, or 1-and-5; therefore, the first tap to ring *2* will start at bar *1* plus 4 equals bar *5*. The other taps will be on bars *5, 37, 69, 101, 133, 165, 193*, and ring *3* will start at bar *5* plus 4 or *9* and connect to bars *41, 73, 105, 137, 169, 197*. Ring *4* will connect to bars *13, 45, 77, 109, 141, 173, 201* and ring *5* to bars *17, 49, 81, 113, 145, 177, 205*, etc.

With the two-layer type of cross connector, the spacing also determines the number of connectors that can be used with any given winding.

For example, consider Fig. 8 which shows a 36-bar commutator for a six-pole machine. The equalizer pitch will be $36 \div 3 = 12$, or 1-and-13. Three equalizers are shown connecting bars *1, 13, 25*, which is practically a three-tap ring, except that each circuit or ring consists of three parts; that is three "S" or involute-shaped end connectors, arranged in two layers. The dotted lines indicate the bottom part of the connector and the full lines the top part. Now 100 per cent equalization would mean 36 connectors and 50 per cent cross connection would require $0.5 \times 36 = 18$ connectors. The spacing would be $36 \div 18 = 2$, or 1-and-3, as indicated by the dots and small figures in Fig. 8. The figure 1 at the front of bars *3, 15, 27*, indicates that the second series of connectors touch these bars. There is also a spacing of 1-and-4, 1-and-5, and 1-and-7 giving 33 1/3, 25 and 16 2/3 per cent cross connection.

Precautions to Take Against Freezing of Fire Extinguishing Appliances

UNLESS extreme vigilance is exercised the very best installation of fire appliances may suffer temporary disablement from frost. Automatic sprinkler systems, hydrants and all appliances using water for fire extinguishment naturally require special care and attention in winter. The following precautions, which are given by the National Fire Protection Association, Boston, Mass., should be taken, and thorough inspections made, with nothing taken for granted:

See that all portions of buildings are properly heated to at least 40 deg. F. at all times to prevent freezing in any of the sprinkler pipes, particular attention being given to exposed places such as hallways, entries, stair towers, elevator shafts, shipping rooms, attics, roof monitors and skylights, and spaces between ground and first floor and under sidewalks. Examine tanks and all pipes, fittings and valves, whether for steam heating, general water service, or fire protection. Besides seeing that tank heaters are in proper order it is important to make certain that they are of adequate capacity for the tanks they serve. Examine carefully and provide suitable boxing around any pipe lines which may be in exposed locations such as either between ground and first floor, between buildings, or near windows, and so on. Make frequent tests during the winter in order to make sure the piping is free from frost.

Where water barrels, pails, or hand pump extinguishers are located in rooms subject to freezing temperatures, use calcium chloride to lower the freezing point of their contents. The accompanying table shows approximately the temperatures at which water will freeze when calcium chloride (commercial, 75 per cent) is added in the proportions shown to depress the freezing point:

Quantities Used to Make 2½ Gal. Anti-Freezing Solution

Freezing Temp. Deg. F.	Water Gal.	Calcium Chloride Lb.	Calcium Chloride Oz.	Specific Gravity	Deg. Baume
+10	2¼	5	-	1.139	17.7
zero	2⅛	6	4	1.175	21.6
—10	2	7	6	1.205	24.7
—20	2	8	6	1.228	26.9
—30	2	9	2	1.246	28.6
—40	2	10	-	1.263	30.2

The strength of the solution obtained may be tested by using a hydrometer to determine the specific gravity. About a tablespoonful of lime added to each pail will prevent acidity and consequent corrosion. The inside of all containers to be used for calcium chloride solution should be coated with asphaltum paint.

Calcium chloride is recommended in place of common salt because the latter will always rust metals. In an emergency, common salt (not rock salt) may be used when the solution is kept in wooden casks and where temperatures lower than zero F. will not be encountered. Two and three-quarters pounds of salt to each gallon of water should be used, producing a solution having a specific gravity of 1.205.

Anti-freeze extinguishers normally employing solutions which will withstand temperatures as low as 40 deg. below zero require no special attention in cold weather. When extinguishers are not of the anti-freeze type (i.e. are either of the soda acid or foam type) the following precautions should be observed. See that no extinguishers of these types are exposed to temperatures lower than 40 deg. F. Diluted sulphuric acid may freeze at a higher temperature than water; at from 36 to 38 deg. F. there is likely to be material precipitation in the soda solution. The freezing point of the soda solution is practically the same as that of pure water.

Absolutely prohibit the addition of "non-freezing" compounds of any character to the contents of these extinguishers. Extinguishers have frequently been rendered inoperative by this means, and fatalities are on record, due to bursting of extinguishers as a result of corrosion induced by such treatment. The addition of salt or calcium chloride to the soda solution causes chemical changes which defeat the essential principle of operation of these appliances.

To thaw water pipes that have become frozen, wrap the frozen section with cotton cloth and pour hot water upon it until the ice in the pipe gives way. Rags on the floor at the base or under the pipe will absorb the waste water. Good results have also been secured by use of electricity where proper apparatus was available. A burning match, torch or open flame of any description should never be employed to thaw pipes. To wrap the pipes with oil-soaked rags and set them on fire is worse than folly; it is incendiarism.

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of
Electrical and Associated Mechanical Systems in Mills and Factories

Best Wishes for a Happy New Year to All of Our Friends

DURING the past year 558 contributions from 243 readers have been published in the pages of INDUSTRIAL ENGINEER. In addition, many other readers have made suggestions and comments which have been very helpful.

The Editors of INDUSTRIAL ENGINEER take this opportunity of thanking those who have thus co-operated with them in these and other ways that are highly appreciated, and extend to all of our readers and friends, everywhere, the most sincere good wishes for a Happy and Prosperous New Year.

Why Not Take the Shackles Off the Squirrel-Cage Motor?

ALTHOUGH the squirrel-cage induction motor is now widely employed, there are certain hindrances in the way of its fullest use. Principal among these are the limitations imposed by many power companies in regard to the size that can be connected to their lines. While there were good reasons ten or more years ago for setting up rules governing the maximum size of squirrel-cage motors permitted on a power distribution circuit, with slip-ring motors required above that rating, no such conditions exist today and limitations of a bygone day are now out of step with the progress of the electrical art, particularly in the improvements in motor starting and control devices.

Realizing that that there would be a constant increase in the size of squirrel-cage motors used, the electrical control manufacturers long ago set out to devise ways and means to apply this type in its larger ratings so as to overcome the objections offered largely by the power companies. Remarkable results have been accomplished through the automatic operation of squirrel-cage motor starters, but still the power companies show little interest in changing the old rules dealing with current values when starting such motors.

There is no question that this indifferent attitude is holding back progress in the application of electric power and it will continue to do so until antiquated starting rulings are changed. Today it is a well-recognized engineering fact that line disturbance when starting induction motors is caused not so much by the amount of current drawn from the line as by the suddenness of drawing this current. Any rules that specify the amount of current that can be drawn during the starting period without specifying the time element in connection therewith are not only unfair to the squirrel-cage motor but plainly indicate that their sponsors are not keeping up to date on motor and electric control engineering. Moreover, this indifference on the part of power companies is penalizing an electrical application that has been and always will be the greatest factor in building up a station load; namely, motors in the larger sizes.

The squirrel-cage induction motor is, when properly loaded, an ideal type for general purpose application, because of its simplicity and reliability, and if power company rules stand in the way of its possible use some method should be adopted to remove the rule, rather than to remove the motor or bar its installation. Industrial plant operators and managers can do much by collecting graphic voltage and current records of squirrel-cage motor performance and discussing these with the managers and engineers of local power companies, and by bringing the matter up for discussion in the meetings of local engineering societies. If such action fails of success, this is a suitable subject to bring before state regulating commissions having jurisdiction over the service furnished to the public by electric light and power utilities. Certain it is that a ruling that forces the use of slip-ring motors when squirrel-cage motors could be used at a lower cost and provide a suitable application from an engineering and operating standpoint are unjust and arbitrary and need relief. Concerted action on the part of the user, based on sound engineering, will bring about relief.

High Voltage and Dirty Insulation Are a Dangerous Combination

OFTENTIMES it is the overlooking of little things in plant maintenance that causes long delays in production. For example, a flashover recently occurred on the slip rings of a 2,000-hp., 2,200-volt wound-rotor, induction motor forming part of a variable-speed drive in a steel mill. The slip rings were apparently in good condition, but on again applying power to the motor a second flashover occurred.

The secondary voltage across the slip rings at the instant of starting is around 1,100 volts. Knowing this, the electrical superintendent thought the insulation around the rings might be dirty. So the rings were blown out with compressed air and another unsuccessful attempt made at starting. Then various other expedients were tried, such as putting in asbestos barriers between the rings, all of which failed.

Meanwhile the entire mill was down for nearly three hours, causing a serious interruption to production. As a last expedient the troublesome motor was switched to the spare bus in the power house. A separate generator was used to bring up the voltage gradually on this bus and the motor connected to it. In this manner

the motor was brought up to speed without trouble.

The following Sunday, the slip ring insulation was thoroughly scraped and cleaned off, after which it was painted with clear insulating varnish. The trouble did not recur, thereby proving that dirty, carbon-covered, slip ring insulation was the cause of the trouble.

A little cleaning and painting of the insulation of all high-voltage parts will go a long way towards cutting down many of those hard-to-find troubles that run up into long delays.

Low Price Will Not Compensate for High Operating Cost

THE question, "What Comes After the Purchase Price?" which an automobile manufacturer recently used in advertising his car, applies just as well to the purchase of any piece of equipment or supplies used in the operating department of an industrial plant. An automobile purchaser looks into the reputation of the car he buys, because he desires to be sure that it will take him where he wants to go, bring him back, have low operating cost, and stay out of the repair shop. The industrial executive also expects reliability and low operating and maintenance cost of the equipment he buys, whether the service demands operation for 10 hr. or 24 hr. a day.

Operating men who look only at first cost and disregard what may come after usually find that, if they keep accurate records, the after-cost of maintenance over a reasonable period added to the first cost, often exceeds that of the highest-priced piece of similar equipment on the market.

The cost of production delays, with their interference to output and the expense of idle men is an additional expense which should be, but seldom is, charged directly as a part of the cost of the machine.

Examine the Fuse Clips Before You Blame the Fuse

THE necessity of having as perfect a contact as possible between fuses and their supporting clips is so obvious as to admit of no argument. Nevertheless in many cases little attention is paid to this point, with the result that a good deal of trouble is experienced, for which the fuse is unjustly blamed.

As a case in point, when a new installation of 440-volt panel and control boards was put in service some time ago serious trouble from blowing of fuses developed at once. In addition, some of the fuse blocks and cables became so hot that several slate panels were cracked. Overloads were first blamed for the trouble, but careful checking showed that the loads carried on the various boards were not excessive. What was considered to be a thoroughgoing investigation of the whole installation failed to show the cause of the trouble. In the meantime fuses kept on blowing.

Eventually it occurred to someone to check up the fuse clips. Then it was found that the area of contact between the fuses and clips was not sufficient to carry the load current without heating, which resulted in the fuses being heated far above the normal working temperature. When sufficient contact area was provided there was no further trouble.

Blowing of a fuse ordinarily creates an emergency condition which must be met as soon as possible by putting in a new fuse. Under the circumstances it is easy to overlook the fuse clips. If they do not make a firm, low-resistance contact, trouble is almost certain to develop sooner or later. It is inconsistent, to say the least, to solder or firmly bolt all other connections in an electrical circuit and then leave the contacts at the fuses to chance.

A few minutes spent in checking up the condition of fuse clips, cleaning and tightening them when necessary, will save much unnecessary trouble and expense.

Take an Inventory of Equipment That You Need But Do Not Have

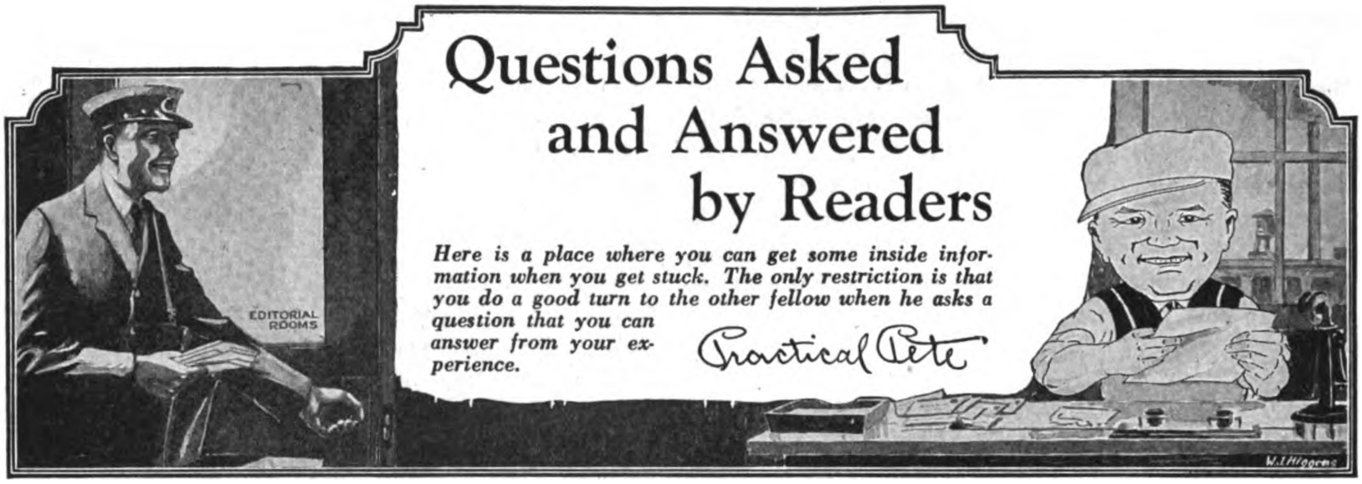
AT THIS time of the year it is the practice in many plants to take an inventory of all equipment and material on hand. For business reasons this is necessary and serves a useful purpose. However, an inventory of the equipment that you need but do not have may show how maintenance and repair costs could be materially reduced.

Probably on more than one occasion during the past year precious time has been lost in an emergency because some tool or piece of equipment that could have been used to good advantage was not available.

Likewise, memory may recall one or more instances where breakdowns of important production equipment could have been foreseen and prevented if the proper testing equipment had been available and consistently used. Again, a few hours spent in watching your men at work may serve to show where up-to-date coil making and baking equipment could replace hand work and clumsy makeshifts at a saving in time and labor; or where an electric drill or hammer could save hours of hard work; or where a few indicating and graphic instruments would take the guesswork out of load surveys and the selection of motors and other equipment; and so on through the manv and varied activities of operating and maintenance work.

It is a mistake to think that there is any real economy in doing by hand work that could be done by machine, or in using inefficient makeshifts, or in simply getting along without equipment that is needed. Under present conditions, in a modern, growing plant, good testing and repair equipment will, when properly used, pay for itself within a reasonable period.

If there is any doubt on this point, put down opposite the price of each piece of equipment that you need but do not have, what the lack of it has cost during the past two or three years, in hand labor and production delays. The result may surprise you.



Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Practical Pete

Who Can Answer These?

Selecting Belts for Oily Work.—We have had considerable trouble with the drives in the screw machine department of our plant due to the belts getting soaked with oil. We have been using leather belts. I would like to know whether there is any treatment I can give these belts to make them oilproof or if there is any belt which is not affected by the oil. Also, how do other men with a similar problem remove the oil from the used belts and put them in condition for service again?

Chicago, Ill. G. F. H.

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Cleaning Wire-Mesh Carbon Brushes—What is the best way of cleaning wire-mesh, carbon brushes that are heavily coated with carbon dust and dirt? Scraping with a knife is slow and not entirely satisfactory. Is there some solution that could be used to clean them? These brushes are used on an old plating generator that is subjected to frequent overloads and the commutator is slightly grooved; so there is considerable sparking. The commutator has been turned down about as much as it can be and as the generator will be replaced before long we do not want to put on a new commutator. However, I must keep the generator in as good condition as possible until it is replaced.

Milwaukee, Wis. A. J. K.

* * * *

Laying Out Electric Repair Shop for Steel Plant.—We are planning to build a new shop for doing our electric repair work. This shop will handle the necessary repairs on motors and control in a steel plant having about 1,000 modern motors both a. c. and d. c. During normal operation 14 men are required in the shop. Naturally the shop will have a coil-winding section; so provision must be made for winding equipment and supplies. In addition there will be a lathe, insulation cutting shear, baking oven, armature press, test rack and other shop equipment. I would like to obtain the views of readers as to what would be the most practical layout of a repair shop for this class of work. Possibly they have found certain arrangements of repair shop equipment that have produced money-saving results.

Indiana Harbor, Ind. A. R. D.

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Reducing Motor Hum on Large Ventilating Fans.—In the operation of induction motors the lower the speed the greater the motor hum. In some cases however, it is necessary to use low-speed induction motors on ventilating fans and in this case excessive motor hum is objectionable since it is transmitted through the fan and to the duct system. If readers have devised ways and means to reduce the transmission of this hum by suitable mountings for motors when direct connected to the fan by using some fibrous or other material that reduces the transmission of noise, I would like to get details of such mountings. Possibly the noise-reducing device may take some form of coupling between the motor and fan. Please indicate also how magnetic density and variations in slip to get low-speed operation effect motor hum.

Omaha, Neb. H. A. P.

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Method of Changing Two-Phase, Four-Wire System to Two-Phase Three-Wire System.—Our power supply is from a two-phase, four-wire system. For various reasons I wish to change the distribution to a two-phase, three-wire system. Will some reader tell me how to determine which wires of the four-wire system should be connected together to form the common or neutral wire? Is it possible to tie together the wrong pair of wires to form the neutral? How should the four-wire, three-phase motors be connected to the three-wire system? Are there any precautions to take in connecting motors to the three-wire system? Will this change affect anything else in the plant?

New York, N. Y. J. M.

* * * *

Armature Bands Overheat.—Five bands are used on a 220-volt, d. c. armature with which we are having trouble. The armature coils slope very sharply and to prevent the outside bands from slipping off the ends of the armature, the winder soldered copper strips across the bands so as to tie them together. Six ⅜-in. strips were placed parallel to the coils and spaced at equal distances around the armature. The bands as well as the copper strips are well insulated from the armature winding, but the bands and particularly the copper strips become very hot, presumably from some induced current. I would like to know what causes this heating and how it may be prevented. If it is induced current that causes the heating please explain what causes this current. Is there any way in which I can tie these bands together that will not cause the heating referred to?

Oelwein, Ia. L. T. M.

* * * *

Starting Large Induction Motors.—The local power company does not permit the connection of squirrel-cage motors larger than 25-hp. capacity to its line. Above this size a wound-rotor induction motor is required. Such a motor and its control are of necessity more expensive. It is my understanding that some forms of resistance starters for squirrel-cage motors will cause the initial current peak to build up gradually and consequently create no voltage disturbance on the power company's lines. If any readers have used such starters on motors larger than 25 hp., so as to meet the requirements of power companies and have successfully shown them that motors larger than 25 hp. can be started without line disturbance, I would greatly appreciate learning the details of the application. I would also like to learn the motor size, voltage, speed of motor, and type and maker of starter in each case.

Cedar Rapids, Ia. H. P.

Answers Received To Questions Asked

Proper Babbitt for Armature Bearings—I would like to learn the experience of other readers as to what kind of bearing metal they find to be most suitable for armature bearings. Is a lead-base babbitt best suited for armature bearings of motors, which are geared direct to the driven machine? With what type of bearing metal do you get the best results on armatures that are direct-connected or belted to the driven machines? There are on the market a great many varieties of bearing metal, including babbitt and various bronze alloys, and I shall appreciate any information that you can give me regarding the selection and application of such metal for use in armature bearings.

Pittsburgh, Pa. H. D.

In reply to the question by H. D., I suggest the use of Westinghouse Alloy No. 14 for his motor bearings. With a proper amount of oil, the motors may be used for any service without fear of bearing trouble.

I would like to hear from H. D., if he does not have good results with this type of alloy.

Oelwein, Ia. L. T. MILLER.

* * * *

Answering the inquiry by H. D., I might say that at one time I was sales manager for a foundry and had a share in the creation of a volume of argument in favor of the use of high-priced, secret bearing alloys. From this experience I can appreciate how confusion may arise when selecting the proper kind of bearings.

Strictly speaking there are only three kinds of bearing metals: (1) soft babbitt; (2) hard babbitt; (3) bronze. Babbitt is used where the bearing is likely to be rebabbitted for longer life and bronze is used where a one-piece bushing is more convenient for maintenance purposes. Unless a bronze bearing is kept oiled it will freeze and cut the shaft, while babbitt will run dry for a time without harm to either shaft or bearing.

In regard to alloys, the best type of bronze to use as listed in most handbooks is given as 88 per cent copper, 10 per cent tin and 2 per cent lead. This is an old stand-by which has not been improved to any great extent. In the case of H. D., he could use babbitt with good results.

Elgin, Ill. SVEND E. SALOMONSON.

Answering H. D.'s question in a recent issue as to what bearing metals are best to use in motors, I recommend a bronze type bearing that has given excellent satisfaction on motors rated from 10 to 50 hp. and operating at speeds between 700 and 1,000 r. p. m.

These bronze bearings are composed of 80 per cent copper, 12 per cent lead, and 8 per cent tin, and are used for motors directly coupled to a reversible drive-shaft by a solid coupling. In boring out these bearings about 0.0025 in. to 0.004 in. clearance depending on the diameter of the shaft, is found to be the most satisfactory. These bearings are lubricated by means of oil rings. A medium grade of machine oil is used.

Long life is one of the chief characteristics of bearings made with this mixture and they have proved their adaptability for elevator use over a number of years.

Asst. Chief Engineer, J. M. WALSH.
Guerney Elevator Co.,
New York, N. Y.

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Answering the question by H. D. in the November issue of INDUSTRIAL ENGINEER, I would like to mention the fact that we have adopted the practice of using Parsons White Bronze metal exclusively for all of our motor bearings. There is no question in my mind, however, that almost any good grade of babbitt with a fairly close grain is satisfactory for motor bearings where the drive is direct, providing there is no side thrust due to gears or belts.

In order to prevent wear when motors are belted or geared to the driven machine, there must be an unbroken oil film between the journal and the sleeve at the point where the side thrust occurs. This oil film may become broken down by oil-ways cut at the point of maximum pressure or where a sleeve is too loose, and not parallel with the journal. Other causes might be rough journals, bearings, or both, and in some cases the grade of oil might be too light to stand the pressure. Most of our drives use either gears or belts, which cause considerable side thrust. We use the white bronze because it is harder than ordinary babbitt and has the very desirable feature of polishing the journal, which in turn causes minimum wear on the sleeve.

Our first application of white bronze metal was made about three years ago on a 100-hp. motor that is used on a coal hoist and operates almost 24 hr. a day. It was thought up to this time that hard bronze was the only kind of material which would stand the weight and service. However, we were putting in new bearings about every three weeks and the journals were so rough they had to be redressed or built up each time, a condition which we felt should be remedied. The first set of white bronze bearings operated eight months and the journals looked like polished tool steel. These bearings have been changed two or three times, but the journals still maintain their polish and so far have required no work on them. We were so well pleased with these results that we commenced using this material in place of babbitt on other motors, with entirely satisfactory results.

We have applications where a cheaper and softer material would serve, however, our motor bearing troubles have declined to such an extent since using this material that it is not worth while stocking another kind. In the end the cost is really no more as the bearings we now use wear longer and have eliminated considerable work on the journals.

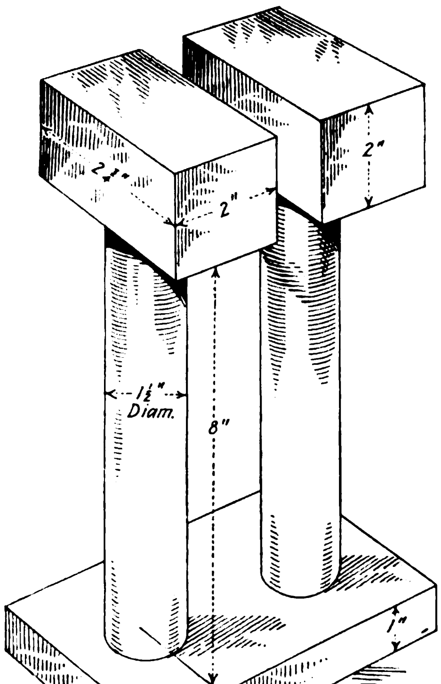
If H. D. is having trouble with motor bearings, I suggest that he first check up on the mechanical details, as mentioned above, to be sure that dirt and grit are not allowed to accumulate in the oil wells; then if this does not eliminate the trouble, try the white bronze bearing metal.

CHESTER A. WILLIAMS.
Providence Gas Co.,
Providence, R. I.

* * * *

How to Make a Magnet Recharger—I wish to build a coil for recharging or remagnetizing magneto magnets. This coil is to operate on 220 volts direct-current. I shall be glad to get any information regarding dimensions of core, turns and size of wire, and so on, that other readers can give me.
Somerset, Pa. G. G. F.

In answer to G. G. F., the accompanying sketch shows an electromagnet for recharging magneto magnets, which has been found very satisfactory and easy to construct. The base is of cast iron 1 in. thick, with two wrought-iron cores 8 in. long and 1½ in. in diameter mounted on it. Each of these cores is wound with 14,000 turns of No. 27 B. & S. gage d.c.c. magnet wire and both coils are connected in series



Details of electromagnet for recharging magnets.

for use on 220-volt d.c. circuits, or in parallel for 110-volt circuits. Where this arrangement is not required, or to make the magnet somewhat cheaper to build, half the number of turns given above and wire of twice the cross-section will make it suitable for service on 110-volt d.c. circuits only.

The two cores are surmounted by wrought-iron blocks, 2 in. high, 2 in. wide, and 2¾ in. long. The complete electromagnet is usually mounted at some convenient point on the work bench so that just the two iron blocks project above the bench. The magneto magnets are recharged by moving them back and forth a few times across the face of these blocks.

Cleveland, Ohio. P. JUSTUS.

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Answering G. G. F.'s question, this magnet recharger may be made as follows: The coils should have 220 turns each of No. 18 or 19 d. c.c. magnet wire wound on solid iron spools. These spools should be about 2 in. in diameter, 5 or 6 in. long and bolted to an iron plate at least ½ in. thick. The coils should be wound in opposite directions and the inner ends connected together. The outer leads should be connected to the power supply through a suitable switching device and fuses.

HARRY J. ACHEE.
Chief City Electrician,
Woodward, Okla.

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How to Determine Horsepower of a Shaft or Clutch.—Manufacturers of couplings, clutches and other transmission equipment rate their equipment in horsepower per 100 r.p.m. Thus a device that will transmit 10 hp. at 100 r.p.m. would transmit 25 hp. at 250 r.p.m. I understand clearly that the horsepower per r.p.m. is the same in both cases. However, it seems to me that the shock to both clutch and lineshaft caused by operating a clutch at 250 r.p.m. would be so much greater than at 100 r.p.m. that a heavier clutch would be required.

I should like to get the opinions of readers on this point. In particular I should like to know what allowances, if any, they make for clutches and other power transmission equipment operating at speeds higher than 100 r.p.m.
Grand Rapids, Mich. E. E. H.

In discussing the question asked by E. E. H. it is well to begin by explaining the purpose of a clutch and other power transmission equipment. In a machinery installation it is often found desirable to have a coupling between certain of the parts, so made that it can be readily disconnected, to render two parts absolutely independent of each other, insofar as motion is concerned.

There are several ways of accomplishing this; one is to use a regular split shaft coupling, which is removed entirely when occasion demands; another is to use a flange coupling with an independent plate between the two halves. When it is desired to disconnect the coupling the bolts are taken out and the plate is removed. This plate is commonly termed a distance plate. A third method is to use what in days gone by was generally termed a dental clutch, so-called because each half had teeth, usually three, projecting from the face which clutched each other when the two halves of the coup-

ling were brought together. Of late years these projecting teeth have been called jaws, and this device is now quite generally referred to as a jaw clutch.

The first two of these devices require a complete stoppage of motion in order to break or make the connection, while the third requires a practical shutdown; so that unless the breaking or making of connections can always be made during regular shutdown periods, their use results not only in very considerable inconvenience, but often in considerable expense because of loss of operating time.

To overcome the necessity of shutting down completely or slowing down, as required by these expedients, the friction clutch was devised, and it has been worked out so successfully that it is used satisfactorily on shafts running not only at normal speeds but also at extremely high rates of speed and can be engaged freely and disengaged without interrupting the motion of the shaft, or shafts, upon which it is mounted. However, the success or failure of the friction clutch is predicated wholly upon the selection of a mechanism which has ample power capacity to meet all of the load conditions which are involved in the installation where it will be used.

The automobile offers a very good example of this particular point, and all that it involves, for it makes use of a friction clutch.

Notwithstanding the fact that the power plant of the car may be fully capable of driving it 60 to 70 miles per hour, the engine will invariably stall if, when the car is standing still, the clutch is engaged in high gear. Here the clutch holds and the engine stops, but that is only because the clutch is always made with power capacity which is in excess of the maximum which the engine can deliver. If the engine were stronger than the clutch, the clutch would slip and the engine would keep on going. In fact, this sometimes does occur, but the driver soon recognizes that his clutch is slipping and takes immediate steps to correct it. Of course, if both the engine and clutch capacities were great enough to overcome the starting resistance offered by the car when "in high" starting in this way could be accomplished, which is the condition usually met in the use of clutches in a factory.

There is usually ample capacity in the factory power supply to handle any pick-up which may be involved in driving any particular machine; therefore the problem comes back to the selection of a clutch which has sufficient power reserve to successfully cover the excessive starting strains which are involved.

Sometimes, as in the case of oil and gas engines and electric motors, the problem in a factory is similar to that in the automobile; that is, the power unit has ample capacity to drive the plant after the machinery is in motion, but it cannot start up under the load and consequently the power unit must be started and be run up to speed before the load can be thrown upon it.

In a case like this the friction clutch must not only be considered from the standpoint of its ability to handle the excessive strains which the picking up a dead load involve, but also on the basis of its ability without frequent readjustments, to stand the slipping which must take place during the picking-up period and before final engagement occurs. Under conditions like this a certain amount of easing in and prolongation of the period of engagement, with the accompanying increase in slippage, must be allowed in order to prevent backing the starting strains into the power unit in such a way as to stall it.

Along with these points, the frequency with which the clutch is operated should be considered for, of course, the more often the operation takes place the greater will be the wear on the friction surfaces. It may seem advisable to use a larger mechanism than might otherwise seem ample in order to increase the area of the friction surfaces. Because the wear is directly dependent upon the pressure imposed upon each unit of friction area, increasing the total area will reduce the pressure on each unit and consequently reduce the wear on the friction surface.

This problem of pressure should also be considered in connection with the bearing surface, which in the case of a clutch pulley runs loose on the shaft, for if the loose hub or sleeve does not possess sufficient area the pressure resulting from the pull of the belt will result in lubrication difficulties and then wear, which will soon cause trouble. This wear is particularly troublesome when the clutch is on the driving shaft, for when it is disengaged the sleeve is standing still on the running shaft, and unless ample bearing area is provided the shaft will wear a pocket in the sleeve along the line where the pressure comes. The sleeve does not always come to rest in the same position, so that, in the course of time there will be worn a series of pockets, which even though very small will be sufficiently large to cause operating troubles. On this account it is well to consider some form of renewable sleeve lining for an installation of this particular type. Babbitt makes a very easily replaceable sleeve bearing surface.

In the cases of the split, flanged or jaw clutches, the matter of selection does not involve any particular problem for these are generally designed to have ample strength to handle all the power which should be carried by the shaft for which they are regularly bored. In the selection of a friction clutch, the situation is different; consideration must be given to the fact that one part of the clutch, and the load back of it, are standing still and must not only be picked up from rest, but also brought up to speed by the other part which is running at a fair rate of speed.

A friction clutch while of necessity allowing a small amount of slippage in the process of engagement, also engages definitely and positively in a limited period of time. If it did not, the friction surfaces would very quickly wear down, so that in order to keep the clutch in shape to function it would be necessary to be constantly adjusting it to maintain the friction surfaces in proper relation to one another.

Because of this fact, the starting loads must be considered largely from the viewpoint that during the period of clutching they produce strains similar to those resulting from instantly applied shock loads. It is for this reason that good judgment dictates overload capacities of two to four times the normal load requirements in clutches which are to be used to deliver power to machines with flywheels, such as compressors and punch presses, and, in fact, any machine which has a heavy mass to start up and bring up to speed.

Clutches running at high speeds or driving high-speed machinery should also be considered in this same way, because starting the load up from rest and bringing it up to a high speed inside of only a few seconds involves starting strains often many times the magnitude of the strains involved in keeping the machinery running properly after it has been put in motion.

It is often found that a clutch is to be used in connection with a pulley which must be of a certain face to match up with the pulley on the machine to be driven, and of a certain diameter to give the machine the proper speed. At the same time it is estimated that the amount of power required to operate the machine is considerably less than the belt running over this pulley can readily transmit. It is always well, however, to select a clutch which is equal in capacity to that which the drive figures, for in 99 cases out of 100 the estimated power requirement is that which is needed to operate the machine after it is running and the wider pulley has been provided by the machine manufacturer so as to insure the installation of a drive capable of taking care of the starting loads which are so much greater than the normal running loads.

If the clutch is not made large enough to handle the starting loads it will not properly function and it will be a constant source of annoyance, not through any fault of the clutch but because of its being called upon to deliver more than its capacity.

Mechanical Engineer, K. W. KNORR.
Dodge Mfg. Corp.,
Mishawaka, Ind.

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In reply to the query by E. E. H., the horsepower of lineshafts is computed from a general formula, depending on the location of the bearings. For example, if there are no bearings to take into consideration the horsepower transmitted by a shaft is equal to the cube of the diameter multiplied by the r.p.m., and the result divided by 50. This will give E. E. H. a better idea of why horsepower corresponds to the speed of the shaft. As for example, assume that a 4-in. shaft (this is for simplicity in illustration because the standard shaft diameter would be 3 $\frac{15}{16}$ in.) operates at the respective speeds of 10, 50 and 100 r.p.m.

According to the above formula the respective horsepowers are:

(1) $4 \times 4 \times 4 \times 10 \div 50 = 12.8$ hp.

(2) $4 \times 4 \times 4 \times 50 \div 50 = 64$ hp.
(3) $4 \times 4 \times 4 \times 100 \div 50 = 128$ hp.

However, if bearings are to be taken into consideration they are usually considered as existing every 8 ft. and the formula becomes: cube of the diameter, multiplied by the r.p.m. and divided by 75 (instead of 50). A common-sense allowance is made, in addition, for bearing spacing other than the 8 ft. mentioned above.

Aside from shafting, one has to take into consideration the gear speed, pitch of gears, and kind of gears, which range from ordinary gears to cast steel and double herringbone gears running in oil. Consideration must be accorded to the type of drive from the shaft, which may be rope, belt or chain with their accompanying limitations in speed and ability to transmit power.

The chief reason for using rope drive is its economy and ability to transmit power at a distance and at an angle; the amount of power that can be transmitted is limited by the number of ropes. Considerable speed is possible with rope drive.

Belts have the advantage of being able to operate in moist and hot places and have a flexibility of control and a versatility of employment that make them adaptable to temporary or permanent installations. Their thickness and width determine the horsepower and inversely, the speed.

Pulleys have the general limitation of their peripheral speed and the general action of centrifugal force; this also applies to clutches, couplings, and so on, and in general their requirements are such as to approximate the strength of an unbroken shaft without danger of breakage from centrifugal force.

The efficiency of a clutch at any speed depends on its alignment, a point which is often overlooked and seldom checked. This applies to all speeds. One must also consider that a clutch operating at a higher speed picks up its load in foot-pounds per r.p.m. at the same proportion as does the same clutch operating at a lower speed with corresponding lower horsepower delivered.

Any clutch that "grabs" the load should be hoisted about as far from the plant as the junk man can carry it, and the sooner the better. I have a very vivid recollection of such a clutch letting go just as I opened a plant door on a visit, and with the door approximately one-quarter open a ⅝-in. bolt struck it. The remainder of the clutch was wonderfully distributed about the power house, fortunately without damage. But from that day I have maintained that that is no way to greet a visitor. That experience taught me to be skeptical about an imposing entrance to any place containing transmission machinery. This particular clutch was a "load grabber" and ended as all such clutches are wont to do. Conditions and not allowance was responsible, since the clutch was oversize.

A good idea of a load pick-up can be obtained by watching the magnetic clutch pick up its load. The manufacturer uses a switch to control the action of the clutch and valuable information can be had on this type of clutch by addressing the manufacturer.

I appreciate that the question asked by E. E. H. is a general one and I trust that the answer I have given him will prove of benefit, although there are many points to be taken into consideration in applying transmission equipment to a particular job or installation. When one is planning to replace old equipment or put in new installations, valuable data can be secured from any of the manufacturers of transmission equipment.

Newark, N. J. EDWARD JAMES.

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In reply to the recent question by E. E. H., the items of excessive wear due to high speeds and shock of starting are considered when determining the horsepower of a lineshaft or clutch, or at least they should be, when figuring the power for high speed, and a liberal allowance made. For shafting the use of formulas is recommended. Shafting transmitting torque may be divided into three classes according to the kind of stresses to which they are subjected:

(1) Shafts subjected to torsion.
(2) Shafts subjected to bending.
(3) Shafts subjected to torsion and bending.

Due consideration must also be given to shaft deflection both angular and linear, or in other words the shaft must be stiff enough for the purpose. In calculating shafting for pure torsion it it customary to use the following unit stresses:

Main power shafts—4,000 lb.
Line shafts with pulleys—6,000 lb.
Small short shafts, torsion only—8,500 lb.

The inch-pounds torque may be calculated from the following formula:

(1) $Hp. \times 63{,}025 \div r.p.m. =$ In.-lb. torque.

The size of shaft may then be determined as follows:

(2) (In.-lb. torque) $\div (0.196 \times d^3) =$ Unit stress.

The above two formulas may be combined into one formula which will shorten the time of calculation:

Main power shafts, $Hp. = (d^3 \times r.p.m.) \div 80$.

Lineshafts with pulleys, $Hp. = (d^3 \times r.p.m.) \div 53$.

Small, short shafts, torsion only, $Hp = (d^3 \times r.p.m.) \div 38$.

No allowance is made for the weakening of the shaft by the cutting of a keyway. Keyways reduce the strength of a shaft in torsion about 18 per cent.

Shafting with bending stresses is calculated first by determining the bending moment and torsional moments separately, combining the two into one stress called "equivalent twisting moment," and then substituting this value in formula (2) as in.-lb. torque.

(3) $T_0 = M + \sqrt{(M^2 + T^2)}$

Where: $T_0 =$ Equivalent twisting moment; $M =$ Bending moment; $T =$ Torsional moment. Assuming stresses of 6,000, 8,000 and 10,000 lb. per sq. in. is common practice in calculating equivalent torsional stress in shafting.

Shafting should not have an angular deflection of more than 1 deg. in 20 shaft diameters. It is good practice to add ⅜ in. to ⅝ in. to the shaft diameter for angular deflection.

$(583 \times T \times L) \div (D^4 \times G) =$ Angular deflection. Where: $T =$ Torsional moment; $L =$ Length shaft twisted in inches; $d =$ Shaft diameter in inches; $G = 12{,}000{,}000$.

Shafting may also be subjected to linear deflection and when the stress is exactly between the two bearings the deflection may be calculated with the following formula:

[(Load in pounds) $\times$ (Span in inches)^3] $\div$ [$48 \times 29{,}000{,}000 \times$ (Moment of inertia)] = Deflection.

According to good practice, shafting should not have a linear deflection of more than 0.01 in. per foot of length.

The use of a brake test is recommended to find the load that will slip the clutch at a given pressure per square inch of friction surface. This pressure varies from about 10 lb. to 100 lb. per sq. in. The greater the pressure the shorter will be the life of the friction material and other parts of the clutch. A pressure of 25 lb. per sq. in. is recommended for clutches of the type used with general transmission machinery.

The load required to slip the clutch can be determined with a prony brake or by securing the clutch to a stationary shaft having an arm attached to the loose member of the clutch and the weight hung from the end of the arm. After the shaft and clutch are ready for the test, arrange to have the right pressure applied to the sliding collar, when placing the clutch in gear to get the required pressure on the friction surface. After finding the weight that slipped the clutch, proceed to figure the power as follows. Assume that the lever is 4 ft. long, measuring from the center of the shaft to the center of the weight suspended on the end of the lever. The circumference of a 4 ft. radius will be 25 ft., less the fraction. Suppose the result of a test made with a 4 ft. lever showed that 300 lb. weight was required and say the speed of the clutch was 100 r.p.m. Assume, $A =$ Circumference (approximately 25 ft.); $B =$ Weight (300 lb.); $C =$ Revolutions (100 r.p.m.). Then $(A \times B \times C) \div 33{,}000 = 22.91$ hp.

For those wishing to arrive at a safe rating for various speeds and figuring from the rate given at 100 r.p.m., starting with a speed of 200 r.p.m., a clutch having 10 hp. at 100 r.p.m. will have 20 hp. at 200 r.p.m. From the 20 hp. deduct 5 per cent. The power at 250 r.p.m. will be 25 hp.; from this deduct 10 per cent. For the next increase of 50 r.p.m. the deduction will be 15 per cent. Continue in the same manner to speed limit.

There are conditions that cannot be taken care of by the instructions given, such as heavy starting loads, pulsating loads, continuous service, and clutch to be placed in and out of gear at short intervals. For extreme conditions the information should be given to a competent engineer to decide the power of the clutch required to obtain good service. J. L. LEMLY.

Manager, Clutch Department,
W. A. Jones Foundry & Machine Co.,
Chicago, Ill.

Method of Cleaning Skylights and Windows.—In our plant we have a serious problem in connection with the cleaning of skylights, transoms in monitor roofs and above the first floor, large windows with steel sash. I wish some readers would tell me what solutions they use for such cleaning, and describe any easily-constructed scaffolding or other method which they use to get to this large area of glass. This has been a very expensive and unsatisfactory procedure with us so far and I would like to know what others do.
Indianapolis, Ind. J. F. H.

Replying to the question asked by J. F. H., we have had experience with all kinds of acids and solutions, but the best thing that I have come across is "Skybryte," which is a solution manufactured by the Skybryte Co., Cleveland, Ohio.

I do not know the exact ingredients, but I do know that it does not injure paint or metal work.

I would suggest that J. F. H. have this manufacturer send a representative, who will not only give him information in regard to the solution, but will also give him practical information regarding the scaffolding, which he also requests.

Cleveland, Ohio. J. E. KALIS.

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Answering J. F. H.'s query regarding the cleaning of windows set in steel sash and located above the first floor, the difficulty of reaching them may be overcome by installing a monorail track at the coping of the building and suspending from this a car designed for the purpose. At first thought this may seem to be a round-about way to perform this job, but at several power plants where the writer has seen this system used, its first cost has been soon offset by the savings made. The car is so arranged that it can be either raised or lowered by hand power or by a motor drive, and a similar arrangement is used for propelling it around the building.

Master Mechanic, B. C. SCHLEGEL.
The Mechanical Rubber Co.,
Cleveland, Ohio.

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Calculation of Rotor Winding for Squirrel-Cage Motor—I have a 1-hp., 220-volt, Type RI, single-phase, General Electric motor, which I wish to rewind for three-phase operation. I have calculated the winding for the stator, but do not know how to go about figuring the squirrel-cage winding for the rotor. Can any reader give me some help in this matter?
Oakland, Calif. B. B.

Regarding B. B.'s question, the best method to follow in this case is to use the old rotor winding as a base. In all repulsion-starting types of motors, the rotor winding is short-circuited at a certain speed. After this stage the rotor acts as a squirrel-cage winding, having the correct distribution of current to provide the required running and pull-out torque, with a certain per cent of slip.

The first step in changing the wound rotor for three-phase operation, is to remove the brush rigging and short-circuiting device. The latter includes all springs, weights, and the copper necklace, when used. Next, turn and polish the commutator, put a bronze wire band on this clean surface, and solder it to the commutator. On radial commutators the band will have to be put on the narrow width of the necks so as to obtain a substantial job.

The above procedure will give the same results as a squirrel-cage winding and if greater starting torque is required the turns per coil and size of wire can be varied. More turns of a smaller size of wire will increase the starting torque and increase the full-load total losses, while less turns and a larger size of wire will decrease the starting torque, increase the starting current and decrease the full-load losses. If it becomes necessary to rewind the rotor, due to a burned-out winding, or to change the starting torque, the commutator can be removed from the rotor and the ends of each coil connected together, so that each coil becomes a short-circuited loop.

When rewinding, consider the coils per cell as being all in parallel. For example, assume a rotor having 37 slots and 111 commutator bars or three single coils per cell, each coil consisting of three turns of one No. 12 d. c. c. wire. Now when the rotor is short-circuited, the three coils are in parallel or equivalent to 37 coils, each consisting of three turns of three No. 12 d. c. c. wires in parallel. This point should be remembered when rewinding in order to change the torque and will enable B. B. to meet any starting conditions with a suitable winding.

Wilkinsburg, Pa. A. C. ROE.

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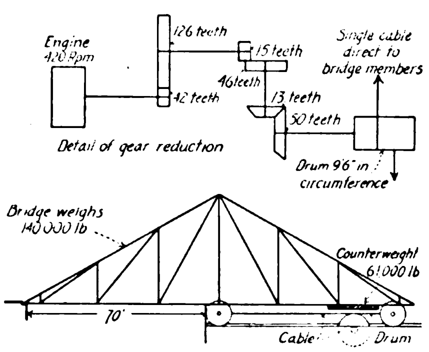
Size of Motor Required to Operate Drawbridge—I wish to know how to determine the size and speed of motor required to operate a drawbridge that is now operated by a steam engine. The diagram shows the general layout of the bridge. It weighs about 140,000 lb. and travels 70 ft. in 45 seconds. It is supported on four steel wheels 30 in. in diameter with a 12-in. face, running on steel rails. The bridge is pulled back and forth by a steel cable running on a drum which is driven by the engine through a gear reduction; this could be changed to a worm gear



if necessary. The speed of the engine is 420 r.p.m. while the drum turns at 10 r.p.m. I do not know the horsepower of the engine, nor is it equipped to take an indicator card, but the following data may help: Duplex engine (both cylinders receive same pressure); steam pressure, 50 lbs. per sq. in.; cylinders 8 in diameter by 10-in. stroke; speed 420 r.p.m.; non-condensing.

It will be necessary to use a two-phase, 60-cycle, 550- or 2,200-volt motor. I shall be very grateful for any help readers can give me.
Quebec, Que., Can. W. S. B.

Replying to W. S. B., the power required to propel a drawbridge weighing 140,000 lb. plus the weight of a counterweight of 61,000 lb. can be determined from the formula:

$$Hp. = (W \times L \times S) \div (33{,}000 \times e).$$

Where W=total weight of structure in tons (201,000÷2,000).

L=lb. per ton friction (assume 30).

S=speed in feet per minute.

e=Combined efficiency of gearing, rope friction, etc., say 0.8.

If the speed of the drum is 10 r.p.m., and the circumference is 9.5 ft., the speed of the bridge is 9.5×10=95 f.p.m.

Therefore, $Hp. = (201{,}000 \times 30 \times 95) \div (33{,}000 \times 0.8 \times 2{,}000) = 10.8$ hp.

It should be noted that the above calculation is made on the assumption that friction is on the basis of 30 lb. per ton. If the wheels bind on the rails this value may be 60 lb. instead of 30 lb., and the horsepower required to propel will be twice as much.

To determine the horsepower rating of the motor, a rule of thumb method is to multiply the horsepower required to propel by two, and use the nearest standard rating. In this case 10.8 hp.×2=21.6 hp.

A 20 hp. motor should be about right. The reason for multiplying by 2 is because a heavy structure, like a bridge, with large inertia may require a large amount of power to accelerate it although a comparatively small amount is required for propelling it after it is up to speed.

A closer check, taking account of the WR^2 values of the different masses being accelerated would be as follows:

WR^2 of bridge=(201,000÷0.8) × $[95 \div (2 \times 3.1416 \times 810)]^2$	87.5
WR^2 of gears and other rotating parts (assumed)	2.0
WR^2 of rotor of motor	15.0
Total WR^2 of all moving parts referred to motor pinion	104.5

Assuming the bridge is up to speed in 5 sec., the torque required of the motor for acceleration is only:

$(104.5 \times 810) \div (308 \times 5) = 55$ lb. at 1-ft. radius.

The torque for propelling plus the torque for acceleration is 70+55=125 lb. to be exerted by the motor when bringing the bridge up to speed, where the propelling torque is $(10.8 \times 5{,}250) \div 810 = 70$ lb. at 1-ft. radius.

A 10-hp., 900/810=r.p.m. motor has a full-load torque of 65 lb. and a maximum starting torque of approximately 135 lb. Allowing for loss of torque due to low voltage, this value would be considerably less and under winter conditions when friction is high due to hard grease and presence of snow and ice, a motor of this size probably would not be able to break the static friction and get the bridge moving.

A 20-hp., 900/810-r.p.m., slip-ring type, crane motor will be able to exert a maximum torque of approximately 260 lb., or a little more with normal voltage and frequency applied at the motor terminals. This seems quite a margin over 125 lb. figured above, but besides the possibility of a higher friction than 30 lbs. per ton there is always the possibility of low voltage. The torque varies as the square of the voltage, so that if the voltage happens to be 490 volts instead of 550 volts the maximum torque becomes $260 \times (490 \div 550)^2 = 207$ lb., which does not leave as great a margin for acceleration as is the case when full voltage is present

on the local power company's system.

If either 550-volt or 2,200-volt power is available, I suggest the lower voltage, as a much better proposition can doubtless be secured from the motor manufacturer on both motor and control equipment.

A 900-r.p.m. (synchronous speed), crane-type motor is suggested. This is a standard 60-cycle speed and lends itself satisfactorily to gearing. A higher-speed motor would be cheaper but less satisfactory as far as gearing is concerned.

With a speed of 10 r.p.m. at the drum, the speed at the 42-tooth pinion will be $10 \times (50 \div 13) \times (46 \div 15) \times (126 \div 42) = 354$ r.p.m.

This is somewhat lower than the speed given by W. S. B. as the speed of his engine is (420 r.p.m.). Since the motor speed is going to be a little more than twice the engine speed, the 42-tooth pinion should be replaced by one having a smaller number of teeth; or assuming 810 r.p.m. is the correct operating speed of the new motor, $42 \times 354 \div 810 = 18$-tooth pinion.

R. F. EMERSON.

Industrial Engineering Dept.,
General Electric Co.,
Schenectady, N. Y.

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Answering W. S. B. regarding size of motor required to operate a draw bridge, the data furnished are not complete enough for an accurate estimate of the power requirements. From the cut, it is assumed that the bridge weighs 140,000 lb. and the counterweight 61,000 lb., making a total of 201,000 lb. or approximately 100 tons to be moved. From the unequal distribution of weight on the wheels and the general character of the installation, we will assume the rope pull required to move the bridge on a level track with no wind as 45 lb. per ton. It is further assumed that the time required to move the bridge must remain approximately as before and allow 5 sec. for acceleration and 5 sec. for coasting to stop or an equivalent rate of 70 ft. in 40 sec., or $(60 \times 70) \div 40 = 105$ ft. per min. For convenience, let us take the bridge speed as being 100 ft. per min. Then using the formula $Hp. = (W \times f \times S) \div 33{,}000$.

Where $Hp.$ = rating of motor in horse power

W = weight of bridge to be moved

f = friction in pounds per ton to drive bridge.

S = free running speed of bridge in feet per minute

From this we have:

$Hp. = (100 \times 45 \times 100) \div 33{,}000 = 13.6$. The next commercial size above this would be 15 hp.

The work of accelerating the bridge from rest is found from the formula:

$$Hp. = (W \times S^2) \div 31{,}680 \times 0.85 \times t$$

Where W and S have the same values as in the previous formula and t = time in seconds taken to accelerate the bridge from rest to full running speed, which we assumed above at 5 sec. then,

$$Hp. = (100 \times 100^2) \div (31{,}680 \times 0.85 \times 5) = 7.4$$

This figure combined with the 13.6 hp. found from the first formula would indicate that a 20-hp. motor would be required in this particular case.

The drum being 9 ft. 6 in. in circumference would be almost exactly 3 ft. in diameter. At a uniform bridge speed of 100 ft. per min. the drum would be revolving at the rate of $100 \div 9.5 = 10.5$ r.p.m. Selecting a motor running at 870 r.p.m. the gear reduction would be $870 \div 10.5$ or 83 as against 40 in the existing installation. This change in over-all gear ratio would, of course, have to be taken into account in redesigning the installation. A Westinghouse 15-hp., 870-r.p.m., type CI motor has a rated torque at 1 ft. radius of 95 lbs., whence the torque at 1 ft. radius at the drum would be 95×83 or 7,880 lbs. or $7{,}880 \div 1.5 = 5{,}250$ lbs. rope pull at 100 per cent efficiency. The actual rope pull required with no wind under the above mentioned assumption of 45 lbs. per ton is, $45 \times 100 = 4{,}500$ lb. This would allow an efficiency of the complete gear train of $4{,}500 \div 5{,}250$ or 86 per cent.

This is quite high as the efficiency of such machines rarely runs over 70 per cent and since no allowance was made for wind load it would probably be advisable to install at least a 20-hp. motor, which is rated at 125 lb. torque at 1 ft. radius. This latter rating then would check fairly closely with the combined requirements of acceleration and propulsion. This would give 6,900 lb. theoretical rope pull and would allow $4{,}500 \div 6{,}900 = 65$ per cent efficiency for the gearing. The maximum starting torque for this motor is 230 lb. and the maximum running torque is 288 lb. so that considerable leeway is available for wind loads and unknown factors. Such a motor would have a wound rotor and would be a ½-hr., 50-deg. C. rating.

If wind load is to be considered, allow 10 lb. per sq. ft. of projected area in the direction of travel and add this to the tractive effort of 4,500 lbs. required with no wind and compute again, using the following formula $T = (5{,}250 \times hp.) \div r.p.m.$

Where T = torque on motor shaft in lb. at 1 ft. radius.

hp. = rating of motor desired

r.p.m. = revolutions per minute of motor shaft.

If a worm reduction gear is used the size of the motor would have to be increased still farther, as the efficiency of worm gearing goes as low as 20 per cent. However, there might be some advantage in a low-efficiency worm gear, as in general the lower the efficiency the more nearly self-locking the worm becomes, and hence less braking is required. It is standard practice to use shunt-wound, magnet-operated brakes operating on the shaft of the motor. The brake torque should be equal to or greater than the full-load torque of the motor used and should be capable of holding the bridge still against a wind force of 30 lb. per sq. ft. of projected area. A reversing three- or five-point drum controller with separately mounted resistor should be used and it might be advisable to install a track limit switch also, depending upon the local conditions.

If the above assumption as to total weight of bridge is erroneous and the total including counterweight is only 140,000 lb. the motor rating should be reduced correspondingly.

For a rough check on the size of motor, selected above take the steam engine as it stands and assume a m.e.p. of 22 lb., which is probably high, and therefore the rating obtained below is correspondingly high. Using the well-known formula *Indicated hp.* $= (P \times L \times A \times N) \div 33{,}000$ and neglecting the area of the piston rod, we have

$$Hp. = [22 \times (10 \div 12) \times 3.14 \times 4^2 \times 2 \times 420] \div 33{,}000 = 23.4$$

From this formula we obtain 23.4 hp. per cylinder or a total of 46.8 as the indicated horsepower of the two cylinders. Assuming a mechanical efficiency of 85 per cent for the engines alone, we would have $46.8 \times 0.85 = 39.8$ hp. available at the engine shaft.

This is practically double the size of motor selected above but, as already pointed out, this is probably higher than the actual output of the engines. Then, too, data not being at hand to compute the power required to overcome wind pressure, it may be that the 20-hp. motor selected would not be large enough to take care of this wind load. On the other hand, since the maximum running torque of the motor is over twice the rated running torque, this motor could easily deliver 40-hp. for the 45 sec. it would be in operation, without a dangerous temperature rise.

Fort Worden, Wash. E. I. PEASE.

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Method of Cleaning Motor Winding—What is the best method of cleaning motors that are oil-soaked and dirty? Can they be washed in gasoline and baked out in a bake oven to any advantage? What is the best method of handling the gasoline? Should the armatures be dipped in a trough containing gasoline, or should they be wiped with a gasoline-soaked rag? I would greatly appreciate hearing of any other methods used by readers for cleaning oil-soaked windings, as well as the results obtained by using gasoline for cleaning.

Chicago, Ill. R. W. A.

R. W. A. asks for the best methods of cleaning motors that are dirty.

In cleaning large motors it is best to first remove the heaviest part of the grit and dirt with a coarse brush; if it is just loose, heavy dust a coarse hair brush will be best. In any case the heaviest part of the dirt should be removed before applying any cleaning fluid, as it will be difficult to remove the grit and dirt after they have been moistened. After the heavy dirt has been removed, wipe carefully in and around the windings, especially around the windings next to the frame of the machine with a piece of cheese cloth dipped in gasoline. A common paint brush dipped in the cleaning fluid will prove very satisfactory in cleaning the oily grit that is usually found in the windings next to bearing housings.

In using gasoline, I would suggest that R. W. A. be very careful as to the amount he uses, as it is a well-known fact among maintenance men that under some conditions gasoline will tend to cause the insulation on the

windings to become brittle and crack.

I have found that the use of carbon tetrachloride is very satisfactory for removing oil and grit from the windings. As a matter of fact, it will do a better job of cleaning than will gasoline, and will evaporate very rapidly, before it has a possible chance to soak into the windings, thereby making it unnecessary to put the motor in a bake oven to be dried out. When the motor can be left out of service for a few hours and can be put where the sun can shine on the windings, I think it will be found that cleaning can be done without injury to the insulation.

I do not think it is advisable to dip the windings into a vat or container of gasoline to remove the oil and grit, for the reason stated above. If the entire winding is dipped in any cleaning fluids, a thorough drying out will be necessary.

If it is possible to obtain compressed air or vacuum, it would be better to remove the loose dirt and dust in this way, as both of these methods, suction or blowing, have proven very satisfactory and are recommended by many of the manufacturers of motors and generators.

When cleaning small machines a paint brush and cloths with some kind of cleaning fluid will be found to be the most satisfactory.

I hope that R. W. A., as well as other readers of INDUSTRIAL ENGINEER who may be planning a cleaning expedition, will find the above information useful.

F. J. H. KRAUSE.

Power Maintenance Division,
Southwestern Bell Telephone Co.,
Dallas, Tex.

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Answering R. W. A., I have never dipped an armature for cleaning and do not feel entirely competent to express an opinion on this method of cleaning. If no other method was possible I would resort to dipping, but in my experience I have always found a different way to clean everything from small jobs up to water and steam turbines of good size.

I find that many repair men use waste for cleaning with gasoline. For my part I have found a putty scraper useful for flat work, using hacksaw blades and the like for other parts (and be sure that they are all present or accounted for when the job is completed). I supplement these with stiff bristle brushes ranging from tooth brushes and paint brushes to those with stiffer bristles, and use hard rags for absorbing and wiping in preference to waste.

Generators can be driven by the prime mover and dried by circulating an idle current through the windings. As a matter of fact, I have always tried to arrange cleaning for such times as will allow the generator to be idle and permit thorough evaporation of the gasoline. This will allow the use of the generator for a short period without varnishing windings and serves to dry them out completely before varnish is applied.

I have found no bad results from use of gasoline, and have also used kerosene and benzine in the same way.

The application of the gasoline depends upon the apparatus to be cleaned. For small places and small jobs I have applied it with a blow torch. For larger jobs I have used it in connection with an air supply of approximately 40 lb. per sq. in. It is possible to use too much and if too small an amount is used it resolves into a very dirty, smeary mud.

Newark, N. J. EDWARD JAMES.

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In reply to R. W. A., excellent results in cleaning motors may be obtained by carefully wiping off with rags well saturated with gasoline. Armature and field coils, which were well covered with an accumulation of oily dust and dirt have in this way been put in satisfactory condition for revarnishing.

If the windings are really oil-soaked, as R. W. A. states there is hardly any process which will remove the absorbed oil. In most cases, however, the oil is merely on the surface, and unless the varnish has been charred or cracked, the treatment mentioned will prove satisfactory.

It is well to use a high-test gasoline for this work, as most of the ordinary gasoline has a noticeable oily or greasy content. Be sure that the gasoline has entirely evaporated before starting the motor if it is of the commutator or slip-ring type.

The re-varnishing referred to above should follow a thorough air-drying of the cleaned motor. Use a spirit varnish for this purpose so that grease or oil will not dissolve it and penetrate into the winding. When cleaning with gasoline, if the varnish comes off with the dirt and grease, one may well suspect that the oil has gone through to the windings. This is the result of using a gasoline or benzine varnish for the final outer coating.

Asst. Chief Engineer,
Gurney Elevator Co., J. M. WALSH.
New York, N. Y.

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In reply to R. W. A., there are several good methods of cleaning stators. If the stator is very dirty and oily one method is to wash with gasoline under pressure. An ordinary paint spraying appliance, such as the small portable type used for painting armatures and motors, may be used to advantage. After washing the stator in this manner it should be thoroughly heated and dried out in order to remove such oil and moisture as has penetrated the insulation of the coils. The time taken for this drying process will vary with the condition of the motor; some motors require only 8 or 10 hr., while others require from 24 to 48 hr. This applies to relatively small motors, 100 hp. or under. Larger motors will require more time in proportion.

Another very good method that, while it is a little more expensive is very efficient, involves the use of a regular cleaning fluid such as the cleaning fluid put up by the manufacturers of Pyrene. If this cannot be obtained readily, the regular Pyrene extinguisher liquid may be used. This liquid is an excellent cleaner and evaporates very rapidly. It is safe to use, so far as danger of fire is concerned, but the fumes given off are very offensive and cleaning should be done where there is a plentiful supply of fresh air; otherwise the operator will be made very uncomfortable.

A method which has been used to some extent, but has never met with the approval of very many electrical men, makes use of water under pressure. It has been used on motors that were filled up with dust not containing oil. If an excellent drying oven is available this method may be used with some success, but in my opinion it is best to keep away from the use of water or any other liquid which is slow to evaporate.

If handled by a careful operator, an ordinary, coarse scrubbing brush and a pail of gasoline can be made to give excellent results. After the washing, compressed air can be used to clean out the air ducts, which are usually plugged up. During the past two years the writer has been using a spray gun and gasoline under a pressure of 40 to 80 lb. per sq. in. The pressure used depends upon the condition of the insulation of the coils. If the insulation is old, low pressure must be used; otherwise the tape will be torn off the coils. If the insulation is in good condition and has not been subjected to very much oil, 80 lb. pressure may be used without damage to the tape. We dry the motors out thoroughly before and after cleaning and then give them one or two coats of Sterling black air-drying varnish.

In many old motors where the bearings have been rebabbitted in the plant shop, no provision is made to drain oil from the bearings back into the oil well; consequently it follows the shaft and is blown all through the coils by the fans on the rotors. All sleeve type motor bearings should have a groove cut around the inside at each end and small holes drilled at the bottom to allow oil to drain into the well, instead of following the shaft.

Chief Electrician, LEE F. DANN.
Donnacona Paper Co., Ltd.,
Donnacona, Que., Can.

* * * *

In answer to R. W. A., regarding methods of cleaning oil soaked motors and windings, we use a gasoline spray gun that can be bought in any automobile accessory store. This gun is used with an air pressure of 60 to 80 lb. per sq. in. The gasoline is contained in a bucket. A hose attached to the gun dips into the gasoline and serves to conduct it to the gun. The latter is provided with an adjusting screw so that the spray can be regulated as desired. We get very good results by the use of this outfit.

One of the chief advantages is that the windings do not become soaked with gasoline, as in the case when they are dipped. Soaking in gasoline has a tendency to injure the insulation of the coils.

When applied by the spray gun, the gasoline evaporates very quickly. When the windings are dry, it is a good idea to coat them with a good air-drying insulating paint or varnish. This should be allowed to dry thoroughly before the motor is put back into service.

Chief Electrician, H. CHARLTON.
E. I. du Pont de Nemours & Co.,
Newark, N. J.

Electrical Service

around the works

For this section short articles describing ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing, and emergency or special installations.

How an Emergency Contactor Was Made From a Hinge

IN AN emergency, a novel expedient was used to provide a direct-current contactor for a control panel. The contactor which had been in service was so badly burned and worn that it would no longer function. Failure occurred on a Saturday morning, and the motor on which the control was used was needed for emergency work all that afternoon, that evening and the next day. No other contactor was available. On searching through the shop an old strap hinge and a few other parts were discovered, including a 230-volt contactor coil. The coil had an iron core, one end of which was tapped for a 10/24 machine screw. We conceived the idea of making up an emergency contactor from these parts.

The iron pin holding the two parts of the hinge was removed and a brass pin substituted so as to keep down as much as possible any magnetic drag which might exist at the hinge point. The space between the two sections of the hinge was increased sufficiently to allow the insertion of brass washers to keep the two halves in line and also to prevent an iron to iron contact that would cause a magnetic drag. One half of the hinge was bent at right angles, as indicated in Fig. 1 and one of the holes originally intended for a screw was used to hold the coil fast to this half of the hinge. The remaining holes in this half were used to bolt the completed contactor to the base. Fig. 2 shows what each screw hole in the hinge was used for.

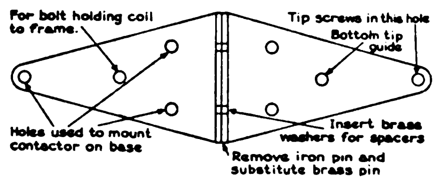


Fig. 2—The iron hinge pin was replaced with a brass pin to reduce any magnetic drag that might exist.

Brass washers were inserted as indicated between the edges of the straps where they rub against each other at the hinge point. The screw holes in the hinge straps were utilized in forming the contactor, as is shown in the diagram.

The other half of the hinge was used as an armature and a pin was placed in the outermost hole to hold the contact in place by means of a spring, as shown in Fig. 1, and thereby allow a small amount of wipe on the contact points. This spring also aided gravity in pulling the armature away from the coil when the contactor opened. The hole in this half of the hinge, which corresponds to the hole in the other half used for holding the coil in place, was used to hold a pin which kept the contact fastened to this half from moving sideways. The movable contact was carried on a piece of flat brass about ⅛ in. thick and ½ in. wide which was bolted to the top of the armature as shown in Fig. 1.

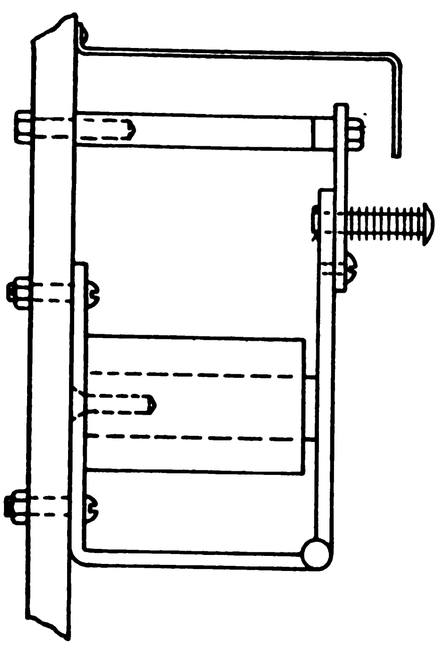


Fig. 1—One strap of the hinge was bent as shown to form the frame of the contactor.

The other strap formed the armature. A contact held by a spring is fastened to the end of the armature. The stationary contact, with which this engages, was made from brass rod ⅛ in. in diameter.

For the stationary contact tip a piece of ½-in. diam. brass rod was used, one end being drilled and tapped and a screw inserted to hold the tip rigid on the base as shown in Fig. 1.

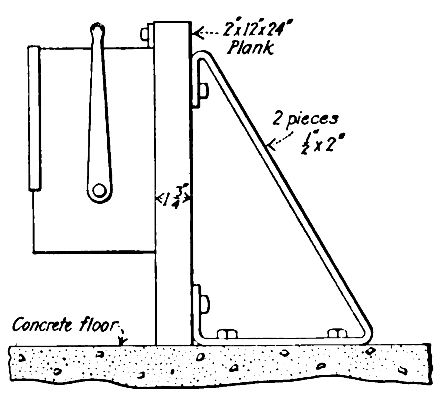
As the contactor was to carry only 7 to 10 amp. a flexible shunt was soldered to the brass piece, carrying the movable contact tip, and was run to a stud on the panel. A strip of brass was bent, as indicated in Fig. 1, to act as a stop, thus preventing the armature from dropping out too far when the coil was de-energized. Adjustment was provided on the stationary contact post so that the proper travel of the armature might be obtained and, at the same time, a sufficient amount of wipe be provided.

No blowout or arc chute was used. There was a small amount of arcing, but during the three days the equipment operated no seriously harmful effects were noticed and, at the end of that time, the contactor appeared to be in very good condition.

Industrial Control Dept., General Electric Co., Cleveland, Ohio. E. B. SMITH.

Mounting Motor Starter Without Defacing Building

IT IS not until a room is completely stripped of machinery and other equipment that the extent of the defacing and mutilation of the building, due to the erection of the machinery and its auxiliary equipment, becomes apparent. Then for the first time the plant man sees the grooves in the floor, which were cut by trucks, holes which were gnawed in the floor by loose machinery fastenings, posts hacked and studded with nails, and ceiling members which are split at the holes bored in them to suspend various fixtures. These mutilations, which would ordinarily not be noticed, are very obvious when there is not the usual equipment around to overshadow them. Cement floors are subject to more mutilation than wooden floors because the latter are more easily patched and so are generally repaired whenever torn up. Some of these defacements can hardly be avoided. However, what might be termed minor defacements, which are generally due to the installation of small machines or auxiliary equipment such as starters, switches and so on, are generally more numerous and frequently show up more prominently as well as do more permanent



This substantial mounting for a motor, compensator or other auxiliary control equipment may be placed wherever convenient and causes little mutilation of the floors.

damage to the building. More care to prevent this would need to be taken where the equipment in buildings is shifted frequently as otherwise the interior would soon be almost entirely defaced.

The method illustrated on the preceding page for mounting supports for compensators, motor starters, switches and other similar auxiliary equipment, not only provides a substantial mounting but causes very little defacing. Use is made of a piece of 2-in. plank of any length and width necessary. This plank is dressed all over and is held upright by two triangular brackets, which are fastened to the back and secured to the floor by four ½-in. bolts or lagscrews. The starter, or other auxiliary equipment, may be mounted as shown. Such a type of mounting does not deface the floor and is frequently much more convenient than mounting the equipment on a column or wall, which can seldom be done without leaving some defacing mark. Installations of this type may be used for mounting the auxiliary control equipment around wood-working machines, presses, textile machines and other equipment. DONALD A. HAMPSON.

Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

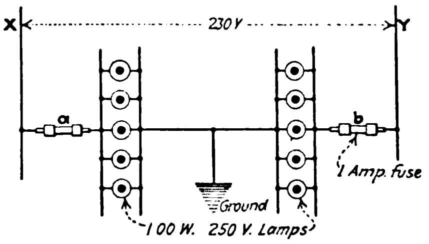
Methods of Testing for Grounds and Faulty Insulation

INSULATION is by far the weakest link in the electrical chain. Failure of it results either in shorts between conductors or shorts between a conductor and an adjacent conductive material, causing a ground. A single ground produces no excessive current flow but subjects the remaining sides of the circuit to an increased potential, which increases the strain on the insulation of this side of the circuit, thereby making an insulation failure at this point more probable. An additional ground, occurring from this or other causes, creates a current flow which, even if small proportionately, soon burns through, making a heavy ground.

Many grounds occur suddenly by overheating and burning, fires, water soaking, damaged insulation, dirt, and the like. Most grounds are produced more slowly by the gradual deterioration of the insulation, although this weakening may be the development of the same causes.

Grounds in electrically-operated plants cannot be entirely prevented. Systematic testing of the insulation throughout the plant well repays the operator in the form of a marked reduction of electrical trouble. The first concentrated effort should be frequent tests of the condition of the insulation. One method quite often used involves the use of a magneto. The magneto, however, is practically limited to a rather rough test of insulation, because it merely indicates whether the insulation is above or below a certain low value. The magneto will often give misleading indications on circuits having even a small electrostatic capacity. Under such conditions it will indicate a short-circuit, even though the insulation resistance may be high. Likewise, the magneto may indicate an open circuit when the circuit is not open. For example, if the magneto is used to ring out a shunt-field coil of a direct-current motor, the bell will not ring, owing to the high induction of the coil. The natural inference would be that the shunt-coil is open. Testing with a magneto in this particular case would not be conclusive.

If regular tests of all circuits are made when the machines are idle, with an insulation testing device such as a megger or megohmer, the condition of the insulation can readily be noted and



A fuse, connected in series with the ground detector lamp, blows when a ground occurs.

By using ten 100-watt, 250-volt lamps connected to a 230-volt circuit as shown, a current of 0.92 amp. is normally drawn from the line. This is not sufficient to blow the 1-amp. fuses shown at *a* and *b*. In case a ground occurs on one side or the other of the line, one bank of lamps is subjected to full line voltage, thereby raising the current through it to 1.84 amp. and blowing the fuse.

recorded. By comparing the values of insulation resistance obtained with those taken on previous tests, a good idea of the condition of the insulation may be obtained. Evidence of deterioration gives a warning sufficiently in advance to allow ample time for repairs.

Much time can be saved during such testing by closing all switches and testing at the bus bars. Should this group method show up serious trouble, the general location of the fault can then be determined by eliminating, consecutively, sections of the system. This method is particularly valuable for testing the bus, switch gear, distribution cable, transformers and other large equipment.

As previously indicated, this method is not a cure-all and should be augmented by tests for actual grounds during the operation of the equipment. A ground at one point of a system shows on all units directly connected into the system at that time. Familiarity with the period and cycle of operation of various machines gives, in many cases, a good idea as to the location of the trouble by its effect at the center of distribution. A multiplicity of equipment of similar operating characteristics, however, requires more thought and more splitting-up during the test.

Lamps or voltmeters arranged for permanent or multiple connections from bus to ground, are frequently used as ground indicators. Use of this method requires that someone be watching the voltmeters or lamps at the particular instant that the ground comes on. For that reason, this method is very limited, as many grounds will occur unnoticed, particularly those of more or less intermittent character.

Various connections of lamps or resistors with fuses, as shown in the accompanying diagram, overcome this objection to some extent, but not entirely. In the case illustrated, two sets of five 100-watt, 250-volt lamps are connected in series across the 230-volt supply. The connection between the two sets of lamps is grounded. Fuses of 1-amp. capacity are connected in series with the lamps at *a* and *b* as shown in the diagram. Under normal operation using 250-volt lamps on a 230-volt circuit, a current of 0.92 amp. would be drawn through the fuses by the lamps. This is not sufficient to blow the fuses. In case a ground occurs on either side of the line, one set of lamps will be subjected to full line voltage instead of half line voltage, thereby raising the current through that set of lamps from 0.92 amperes to 1.84 amperes. This current would blow the fuse for this set of lamps, thereby giving a permanent indication of a ground existing on the side of the line opposite that to which the fuse is connected. The writer has used this scheme with very good results. A non-renewable fuse will be found preferable for use at *a* and *b*.

The use of graphic meters, with the advantage of continuous records, appears to be the best method for detecting actual grounds. An excellent article by R. H. Bahney, describing the use of graphic meters on direct-current circuits appeared in the September, 1925, issue of INDUSTRIAL ENGINEER. The use of graphic meters on alternating-current systems may prove more complicated. If the electrical system consists of several banks of transformers without secondary tie lines it will, of course, be necessary to install and maintain at least one alternating-current graphic voltmeter on each secondary distribution circuit.

Other devices for testing grounds have their field of usefulness, due particularly to the fact that they are compact, handy and sufficiently accurate for quick work. The magneto is found in nearly every maintenance shop. It is most useful, however, in shooting trouble after the breakdown occurs. A handy device for testing for grounds as well as other circuit troubles, is the pocket tester made by the Electric Tester Mfg. & Sales Co., Portland, Ore. This pocket tester is of the multi-voltage type and consists of a small lamp together with suitable resistance and tap arrangement for testing all standard voltages, both a.c. and d.c. up to 600 volts. There is also a pocket voltage tester (made by the Square D Co.) which consists of a small solenoid and plunger mounted in a fibre tube. An indicator fastened to the plunger and working through a slot in the tube, indicates voltages ranging from 110 to 600 volts both a.c. and d.c.

A companion to these two for testing higher voltages is the spark gap tester, known to the trade as "Spark C" (made by the Westinghouse Electric & Mfg. Co.). This tester is generally used for testing the ignition system of

gasoline engines, and has the big advantage of safety in testing high-voltage circuits. It is not necessary to touch a live conductor. If the tester is brought close to a live conductor, the tube will glow. This glow will occur even through the ordinary cable insulation or porcelain insulator or other types of insulation. A conductor of zero or low potential will not produce a glow in the tester and thereby shows the presence of a ground, open or other fault disturbing the voltage balance of the system.

Grounds are frequently located by resistance measurements of the copper conductor from some accessible point to the grounded portion. For this purpose the Wheatstone bridge, or modifications of it have been used for many years.

In the repair shop, motors and other electrical apparatus are generally subjected to a voltage higher than rated voltage to determine the condition of the insulation. Should a weak spot be present, it is broken down and its location readily found. When followed by repairs, this practice saves considerable time, but in general the method is too destructive to be used about the plant, unless it is apparent that the apparatus will probably have to be taken from service for replacement with new equipment.

The size and layout of a given plant, together with the cost of production delays will greatly assist in determining which of these methods will be best. For this reason the various methods of testing have been compared with each other. R. N. VINING.

Electrical Engineer,
Detroit Seamless Steel Tubes Co.,
Detroit, Mich.

Inexpensive Way to Prevent Starting Shunt Motors on Weak Field

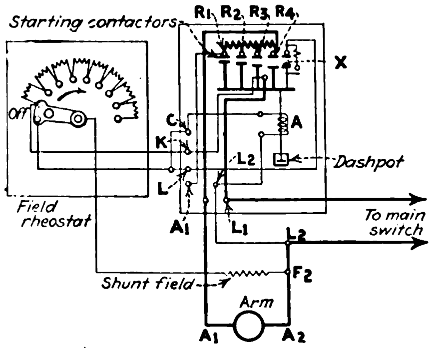
IN MANY plants where old-type, manually-operated, control is in use, a problem that often confronts the electrical superintendent is how the change to automatic control can be made without running up the maintenance costs; the management oftentimes considers that so long as the manual control is starting the motors, no change is necessary.

In some cases, when the idea of automatic control has been sold to the management and a quotation received from the control manufacturer, the price is found to be so high in proportion to that paid for manual control, that the change is pigeon-holed until the brighter days of better business. This being the case, it is sometimes necessary to do a considerable amount of figuring to obtain a satisfactory automatic controller and still keep the purchase price down.

As a concrete instance, I will cite a particular case where some money was saved. A 5-hp., 400/1600-r.p.m., 230-volt motor was used to drive each stoker grate in a large boiler house of a steel plant. The control installed with these motors consisted of standard starting and speed-regulating rheostats in which the contact arm is moved across the faceplate thereby cutting out the starting resistance and then moved back in the opposite direction to give speed control.

Considerable trouble was experienced with these starters, chiefly due to their being operated by foreign labor. After three or four years' operation there was little of the original starters left, and a considerable amount of money had been spent in keeping them operating.

In looking about for a new type of starting equipment it was decided that a time-limit acceleration starter, similar to those which had been installed on various drives in the plant, would



The first button on the full field side of the field rheostat was disconnected and connected through (C) to coil (A).

When the field rheostat is in the off or full field position it bridges the first two buttons, as shown. Power flows from *L2* through coil *A* to *C*, thence to the off button, then across the rheostat arm to *K* and to *L1*, thereby completing the circuit and causing the operating coil *A* to function.

be best for the conditions encountered in the boiler house. The only trouble with the time-limit acceleration starters was that no provision was made to prevent the operator from starting the motor with a weak field. Upon taking this matter up with the manufacturer of the starter, it was found that a field relay could be installed, but the price would have to be increased about 100 per cent, which made it prohibitive.

The starters were, therefore, ordered standard and the following scheme worked out to change them when received. The resistance was disconnected from the first stud in the field rheostat and connections made as is clearly shown in the accompanying diagram.

When the rheostat handle is turned to the off position, the operating coil *A* is energized from *L2* through *C* across the rheostat handle to *K* and to *L1*. Thus the coil closes the starting contactors and accelerates the motor. The operating coil circuit is maintained through an auxiliary contact at *X* which closes with the last main contact. The motor can then be speeded up at will by turning the field rheostat arm, thereby cutting resistance into the shunt field.

It will be readily seen that unless the rheostat handle is turned to the off position, the *A* coil circuit cannot be energized; therefore the starting contactors will not close to start the motor.

The starting or stopping of the motor is controlled by a switch ahead of the starter. In the case of power failure, if the rheostat is on the off position for low speed, the motor will start up; if in any other position, however, the operator must first turn the rheostat back to the off position before the motor will start.

This control as changed has been giving satisfaction for the last year and a saving of about $50 was made on each starter. O. C. CALLOW.

Chief Electrician,
The Trumbull Cliffs Furnace Co.,
Warren, Ohio.

Ammeter in Motor Feed Gives Control Over Quality of Product

IN THE drawing of heavy brass and bronze wire a double pull block is frequently used. This consists of a horizontal shaft with a block at each end on which the wire being drawn is wrapped after being pulled through the reducing die. In these days of increased production demands it is advisable to get as much output from each side of the machine as it can safely deliver.

In our case, the double block was driven by a 75-hp., 230-volt, General Electric, variable-speed, direct-current motor. To guard against burning out this motor, due to overload, we installed an indicating ammeter in the line to the motor. The maximum current which the motor could safely draw, was heavily marked in red on the ammeter. The operators were instructed to govern the amount of reduction of wire on the two sides of the machine so that the pointer on the ammeter would not pass the red mark. A rather liberal allowance of 50 per cent overload was made in locating the mark because the operation is intermittent.

Due to changes and expansion in the plant, we have arranged this block so that only one side is used and nothing but Phono Electric trolley wire is drawn on it. We now use the indicating ammeter to obtain greater control over the operation. It is still necessary to have knowledge of the current drawn by the motor when the block is speeded up because, naturally, more power is required for any particular draft with a higher speed, especially when working on this heavy wire.

We have determined, therefore, what speeds should be used on the different drafts of wire and what energy these different drafts should take. Any departure from the normal condition for any speed and draft, which might be due to a variation in quality of the alloy or other causes that would affect the quality of the wire, is indicated at once to the operator, as the ammeter is located so that he can easily watch it. This ammeter has been of great assistance to us in maintaining an even standard of product as it gives us almost laboratory control in the shop itself. E. R. FEICHT.

Plant Engineer,
Bridgeport Brass Co.,
Bridgeport, Conn.

Mechanical maintenance of

Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through the auxiliary transmitting equipment to all driven machines.

Driving Pedestal Emery Grinder With Bevel Gears

FLOOR grinders such as are universally used for snagging, miscellaneous grinding, sharpening tools, ana so on, are usually either belt driven or, if they are new, are of the built-in-motor type. In a machine shop manufacturing conveyors the type of drive was changed from lineshafting to individual motors. What to do with four belt-driven floor grinders was a question which bothered the operating force for some time.

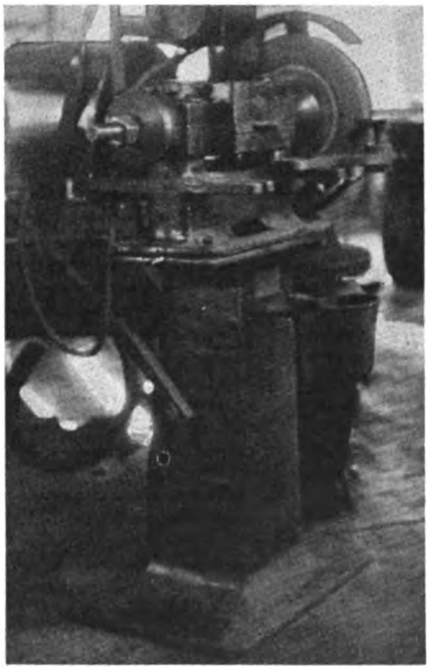
These grinders were good, rugged machines, which were mounted on substantial pedestals, and had proven perfectly satisfactory; new motor-driven machines would run into considerable money, which was an expenditure hardly warranted by the circumstances. However, the master mechanic knew of no "past performance" that suggested any alternative, unless it was to put motors overhead and belt from them to the grinder pulleys. The construction of the machines was such that motors could not be installed between the bearings; at least, the shop did not have the equipment or the experience to do this.

The method of attaching direct drives to these old grinders was a somewhat novel one. However, it was sound fundamentally as is attested by over six years' continuous operation during which time not a single criticism has been entered in regard to these machines. The spindle pulleys on the grinders were removed and bevel gears put on the shafts in the place of the pulleys. A mating bevel gear was placed on the stub shaft of the motor which drives the machine. There is nothing radical about the drive, but many experienced shop men would immediately hold up their hands in horror, and say: "What? A gear drive, and bevels at that, running at motor speed? Why, you couldn't hear yourself in a room with one much less four of them running. Now, a worm —that would be silent; but of course you couldn't get the speed out of a worm drive."

The remarkable part of it is that these gears are not noisy. The machines make no more noise than they did when belt driven. Visitors to the shop often ask about the kind of a drive on those grinders because the grinders are conspicuous and are placed around the shop at odd places as they are moved anywhere that is convenient for use on an erecting job. Both the gears and the motors are enclosed with sheet-metal hoods to protect them from the dust from the grinding wheels.

Three of the machines run at 1,800 r.p.m. and one at 3,600 r.p.m. Current is supplied at 220 volts, 60 cycles from sockets arranged at fixed points for plugging in. A long extension cable is part of each machine's equipment.

The grinder shown in the accompanying illustration is driven by a 2-hp. motor which is supported on a metal frame on the back of the machine and is suitably braced from the pedestal. A lighter frame for mounting the starter is carried upwards. This places the starter in a convenient position between and above the two wheels. These frames are substantial but not elaborate. This machine has a pair of bevel gears 4 in. in diameter, eight-pitch teeth. They do not run in oil, but are merely greased once in a while, and they have not been renewed since installed. Miter bevel gears are used on all drives. This design has proved to be both durable and satisfactory and has saved what would have been a considerable investment in new grinders.



The motor is direct connected to the pedestal grinders through miter bevel gears.

To obtain a more flexible arrangement of the machinery in one shop group drives were replaced by individual motors. The problem of connecting motors to each of four double-head pedestal grinders was solved by installing bevel gears on the grinder shafts which mesh with mating gears on the motor shaft. The motors are mounted at a right angle to the grinder shafts on brackets attached to the pedestal. This installation has operated satisfactorily for six years and saved a considerable investment in new machinery. These grinders are moved wherever they will be most convenient for the manufacturing and assembling operations.

Plant Supt., DONALD A. HAMPSON.
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Belt Maintenance Kinks Which Help to Avoid Trouble

LEATHER belting is one of the most extensively used means of transmitting power in the industrial world today and it is, therefore well to understand its proper care and operation, not only in the large plant, but in the small one as well. Belts respond to good treatment in any plant.

How many plants are not getting the full efficiency of their belts?, and How many are actually abusing their belting?, are questions worthy of note and careful consideration. A large number of cases investigated have shown that only a little, or no knowledge of leather belt maintenance is costing the users a large sum annually in power losses.

The general tendency seems to be to run belts tight, sometimes so tight as to pull countershafts and small equipment loose, and often breaking the belts or stretching them excessively. Because small belts usually give little or no trouble they do not present the problem that the larger ones do, from the load standpoint.

As engineer of a large concern, one of my duties consisted of the maintenance of over 1,700 leather belts from 1 in. wide, up to two large belts 6 in. wide. A large number ran tight and were always giving trouble, as no means had ever been taken to solve the load problem. For four years these belts were treated regularly with Cling Surface belt dressing, and during this period gave satisfactory service. Then a fire damaged the plant.

The engine room and two departments were flooded with water and after the fire was put out it was evident that the water had done the most damage. Many of the belts were supposedly ruined, but on closer examination we found only six belts under 2 in. wide were lost, and by fire at that. The remainder were practically unharmed, as the belt dressing was waterproof. Every one of these belts, with one exception, is running today under a slightly increased load. One

of the large 6-in. belts has been replaced by motor drives.

A few suggestions on the care of belts may help other plant men. A belt should never be put on the pulley with the skin side out as this has a tendency to break down the dressed surface of the belt and weaken the fiber, especially on a short bend. New belts should be treated with dressing sparingly until broken in. After once getting a belt in proper shape with the right treatment it should be run a little slack to get the best results, except on vertical belts which sometimes have to be snug but not tight enough to cause undue strain. These belts are often run to better advantage by using an idler or short-center drive to take up the slack.

Motor belts are often taken up so tightly as to cause undue heating of the motor and rapid wear of the bearings. Proper attention to the belt would avoid this.

Good belt dressing costs money, and many buyers prefer the cheaper brands. This policy of buying inferior dressing is a grave and expensive error in that it is money thrown away. Also, a belt dressing must be applied properly and not too thick. On new belts no trouble is experienced, but on old belts full of grease and other foreign matter, a good dressing will if used with care, finally force all impurities and dirt through the grain and to the outside of the belt where they can be removed easily. This is an important factor and should never be ignored. A great mistake, made by many when using a liquid belt dressing, is that after a few applications, they give up in despair. It often takes weeks of treatment with constant supervision to get a belt in proper shape.

The belt that runs with the slack side the wrong way must be taken into consideration also. If the load is constant the belt can be treated the same as other belts. If it is necessary to take up such a belt, it should never be drawn too tightly. The larger the belt, the better the chance to eliminate power losses by maintaining it at the proper operating tension.

Slipping belts often cause trouble by generating static electricity and have been the cause of a number of fires, by discharging a static spark into combustible gases, dusts, and so on. In several cases, oilers and operators have met with injury as a result of receiving a static discharge which caused them to fall or suddenly jump into danger. All of this could have been eliminated by applying the proper methods of using and treating belts.

Good results may be obtained with canvas and rubber belts by giving them the same treatment with belt dressings, as in the case of leather belts, although the existing conditions must be studied to acertain the extent of treatment needed, and sometimes exceptions have to be made.

Persistent effort and careful analysis of individual belt problems will more than repay those concerned for the time thus spent. Give your belts a chance, and they will do all that is expected of them.

Auburn, N. Y. W. L. JOHNSON.

Keeping Pulleys True Improves Operating Conditions

IN SOME cases it is found that a wood pulley gets out of round after long and faithful service. Frequently this is due to a shock or intermittent load. This out-of-round-ness of the pulley imparts a jump to the belt it drives which is objectionable and accentuates the intermittent or shock load. The belt is under a stress due to the intermittent pull and also because it may have been installed with the short side or radius of the pulley up. In this way the countershaft is kept in constant vibration, and a stress is put on the lineshaft.

Lineshafts which run out of true, as is often the case on lines of shafting with many pulleys on them, are frequently the result of the pull of belts springing the shafts to one side. This is made more pronounced by those out-of-round pulleys which exert a jerk upon the shaft with each revolution. Sometimes this out-of-round condition is due to the wrong use of interchangeable bushings. It is seldom advisable to use bushings of one make with pulleys of other makes, to mix old and new bushings, or to use mixed bushings of different makes. Also homemade bushings seldom run true. In addition there is the natural warping of the wood when exposed for long periods alternately to dampness and heat. Any one or several of these conditions may be the cause of wood pulleys getting out of shape.

Our factory has made a practice of going over wood pulleys and correcting those which are in really bad condition. Any pulley more than ¼ in. out of round is corrected, and on some machines this tolerance is usually cut in half.

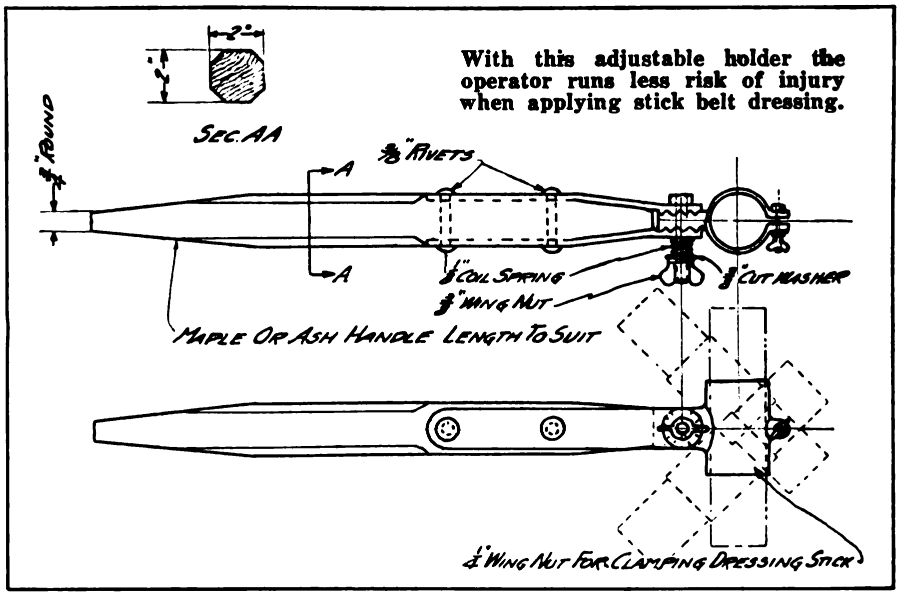
The pulleys are taken down and their periphery turned in the lathe. We have three arbors which correspond to the three sizes of lineshafting in the plant. The pulleys are mounted upon these arbors, using the identical bushings and bolts in the pulley. After being turned, the pulleys are given one coat of orange shellac, which is allowed to dry, and is then sandpapered and another coat applied before they are returned to service. This work is done when the particular machine driven is not in use. The work is ordered on a form which is made out after inspection and notifies the *Maintenance Department* that a certain pulley is to come down when the machine driven by it is taken out of service for sufficient length of time.

Adjustable Holder for Applying Stick Belt Dressing

BELT dressing ordinarily comes in the form of a thick semi-liquid or in sticks. The semi-liquid dressing is usually heated and applied with a brush to the belt when in motion. Stick dressing is held against and moved across the surface of the moving belt and the friction wears or melts off some of the dressing.

Although the stick type of dressing is commonly held in the hand when applied it is a somewhat hazardous process, particularly on high-speed belts, where metal or other fasteners are used, or when the stick is worn short. A safer method, as recommended by the National Safety Council, Chicago, Ill., is to use the adjustable holder, shown in the accompanying illustration, when applying stick dressing. This holder was made by D. S. McEachern, fire and safety engineer, Semet-Solvay Co., for such use.

When applying the dressing, the holder should be held at right angles to the belt. The head of the holder may be adjusted to the proper angle by loosening the ⅜-in. wing nut, adjusting the holder to the position desired, and then tightening the nut. The dressing should be applied to the outgoing side of the belt so that in case the stick dressing should catch on a belt fastener, the holder would be thrown out of the operator's hands and away from the pulley. Also, when applying semi-liquid dressing with a brush it is safest to hold the brush to the outgoing side of the belt at the pulley so that the hand or brush are not pulled into the pulley as would otherwise be the case.



With this adjustable holder the operator runs less risk of injury when applying stick belt dressing.

In the Repair Shop

This section is devoted to repair work on electrical and mechanical equipment. Special attention is given to shop or bench tools and short cuts or improved methods of handling work of this character. Contribution are always welcome.

Wire Used as Gage When Boring Babbitt Bearings

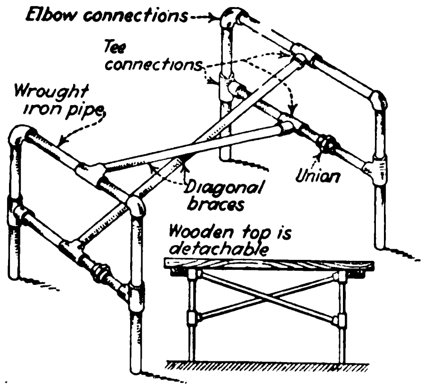
A SPECIALTY factory with no metalworking department has an all-around repairman who does the work of electrician, mechanic, carpenter, and anything else there is to do. Among his activities is the care of a number of motors, even to their rebabbitting. However, he has no lathe and so sends his babbitted bearings to a near-by machine shop for finishing.

The method of obtaining the correct bore is unique. He owns micrometers and measures his shafts accurately. He then takes a piece of wire, points it at both ends, smooths the ends off, and sends it to the machine shop with instructions to bore the hole so that when the piece of wire is held upright in it there will be a swing of $\frac{1}{16}$ in. at the top while the bottom is held stationary. This is a simple and easily-made gage, which so far has given satisfactory results. DONALD A. HAMPSON.

Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Easily-Made Pipe Supports for Workbench

WHERE a small workbench is desired, for either temporary or permanent use, the pipe frame construction, shown in the accompanying sketch, is very satisfactory. This can be easily made up in any convenient width or length, as practically every shop has the necessary tools for doing the work. It is not necessary to use new pipe, as such a bench can be made up of discarded pieces.



This bench support is easily made from short pieces of pipe and standard fittings. If unions are placed in each of the diagonal struts, the supports may be taken apart to make for easier moving.

The method of assembling the legs and the diagonal struts gives a rigid construction. If it is desired to make such a bench portable, unions may be added to the diagonal struts so that they may be easily taken apart. The wooden bench top may be secured to the supports with hook bolts or straps, whichever is the more desirable, especially if the bench is to be taken apart to be moved.

Washington, D. C. G. A. LUERS.

Comment on "Laying in a Chorded Split-Loop Winding"

IN THE September issue of INDUSTRIAL ENGINEER, A. C. Roe shows a diagram of a split-loop winding. I do not understand how the leads are connected to the commutator bars nor what connections are made with leads *1* and *12*, for example. I would like to see a diagram of the winding connected to a 12-bar commutator.

Los Angeles, Calif. JOHN BANTOU.

* * * *

This type of winding can be used for armatures having as many bars as slots when using two wires in hand, or for three times as many bars as slots when using three wires in hand. However, this winding is generally used only with armatures having two or more times as many bars as slots. In the chorded split-loop winding the wire is not cut after winding each coil except to put on sleevings.

One sleeve for each coil is all that is needed for low-voltage machines. The sleeves should be put on all of the starting leads. Then instead of cutting the wire, a loop is made at the end of each coil. One side of the loop should be long enough to use as the finishing lead of the coil just wound, while the other side of the loop forms the starting lead of the next coil. Fig. 1 shows the coils all in place without being cut from start to finish. This is the same as Fig. 2 in the September issue. The beginning of the winding is at the free lead F^{12} in slot *7*.

After testing for opens, shorts and grounds, the next step is to cut open each closed loop, as shown in Fig. 2. This divides the winding into 12 complete coils and each slot contains a starting and a finishing lead, which applies to all two-layer armature windings. The table with Fig. 2 gives the lead numbers in each slot; thus we find the finishing lead of coil *11*, or F^{11}, and the starting lead of coil *1*, or S^1, in slot *1*. These numbers are also used to designate the coils and the sequence in which they are put on the armature.

We now have the windings separated into 12 coils, as in any two-layer winding, except that the formed coils are placed in adjacent slots in consecutive order. The bottom or starting leads and top or finishing leads are brought out in regular order, which makes it an easy matter to lay down the bottom leads. In any hand-wound armature, that is, an armature on which the coils are wound directly into the slots from the reel of wire, the starting leads S^1, S^2, and so on, are considered the bottom leads and the finishing leads, F^1, F^2, and so on, are considered as the top leads.

The next step is to find the bottom leads of consecutive coils in adjacent slots. In hand windings the best coil to start with is the last coil put on which is always visible, such as coil *12* in Fig. 2. The starting or bottom lead S^{12} is in slot *2*. Now assume that in this armature the leads are brought over to the commutator bars on the center line of the coil with lead S^{12} bent in towards the bars between slots *4* and *5*. Using the last coil prevents the chance of making the costly mistake of bending the lead of S^{12} around the opposite side of the armature to bars between slots *10* and *11*.

After sorting out the start or bottom leads from the finish or top leads in each slot, as has been done in Fig. 2, and putting down the bottom leads of the last coil, we next take the bottom

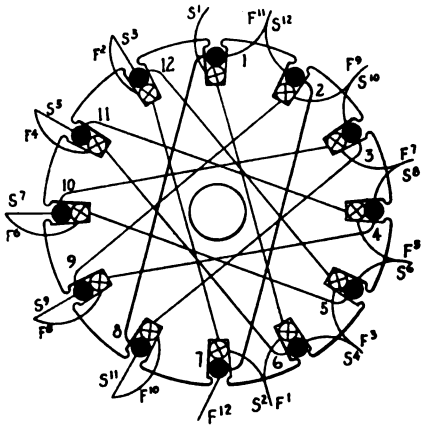
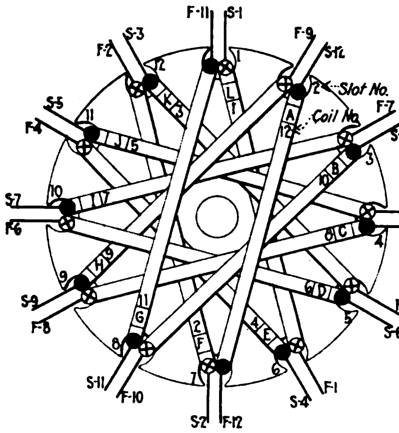


Fig. 1—Complete winding diagram for a chorded split-loop winding.

In this diagram the top half-coils are represented by black dots, while the circles with crosses in them indicate the location of the bottom half-coils. S^1 is the start of the first coil, F^1 is the finish of the first coil, S^2 is the start of the second coil and so on through the winding.

lead in the adjacent slot in a clockwise or counter-clockwise direction. The direction of pick-up does not matter providing we choose a bottom or starting lead each time from an adjacent slot, and that the leads are put in commutator bars on the proper side of the last coil leads. This means that no leads



Slot No.	Lead No. Start	Lead No. Finish	Slot No.	Lead No Start	Lead No Finish
1	1	11	7	2	12
2	12	9	8	11	10
3	10	7	9	9	8
4	8	5	10	7	6
5	6	3	11	5	4
6	4	1	12	3	2

Fig. 2—Procedure in connecting a chorded split-loop winding to the commutator.

Letters *A*, *B*, *C*, and so on indicate the coil sequence and direction of pick-up. Starting leads (S^1, S^2, etc.), and finishing leads (F^1, F^2, etc.), indicate the order of winding. The table shows the leads that are placed in each slot.

should be crossed over the first leads put down, but should be placed in back of or ahead of the first leads, according to the direction of pick-up.

In Fig. 2 the letters *A*, *B*, *C*, and so on marked on each coil indicate the direction of pick-up and the coil sequence. Let us first select the bottom lead S^{11} of coil *A* in slot *2* and put it down as explained above. Then S^{10} of coil *B* is placed in slot *3*; lead S^9, coil *C*, in slot *4*; and so on until all the bottom leads have been laid. If the starting and finishing leads have been properly marked while winding and the coils wound in the correct order, there will not be any chance of mistakes in following the above procedure. Suppose a mistake were made in marking leads F^{11} and S^{10}, for example, and the finishing lead F^{11} of coil *7* or *1* were marked S^{10} while connecting. Then we put down lead F^{11} after lead S^{10} and coil *1* would be in a strong magnetic field when under commutation. This would cause sparking, heating of the winding and jerky operation of the armature.

In Fig. 2 the coil numbers which show the order of winding each coil onto the core are given under the letters, which indicate the sequence of connecting the coils in the proper order to the commutator. Thus, coil *A* is coil *12* or the last one wound and the first one connected to the commutator. Coil *B* is the tenth coil wound on and the second connected; coil *C* is the eighth coil wound on and third coil connected, and so on.

Comparing the winding order, as coils *1*, *2*, *3*, with the order of connecting, the bottom lead of coil *1* is the last bottom lead put down; coil *2* is the sixth coil connected and coil *3* the eleventh to be connected. It is obvious what would happen if the leads were put down in the same order as the coils are wound, or if they were placed without cutting open the loops.

Wilkinsburg, Pa. A. C. Roe.

Simple Device for Removing Pinions or Pulleys from a Shaft

A SIMPLE device which I have found to be very handy for removing pinions or pulley from a shaft is shown in the accompanying illustration. To make this puller, bore a hole lengthwise of the center through a piece of 3-in. shafting, 8 in. long, and tap it for a standard 1½-in. bolt. Make the 1½-inch bolt 22 in. long pointed on one end and square on the other. Thread this bolt for practically its entire length and screw it into the piece of shafting. The pointed end of the bolt should be just sharp enough not to slip out of the shaft center when the puller is in use.

Three pieces of flat iron, ⅝ in. by 2 in. by 10 in., should be welded at right angles to the shafting, as shown, spacing them 120 deg. apart. These pieces should be welded very securely to the shaft as the usefulness of the puller depends on the strength of the welded joints.

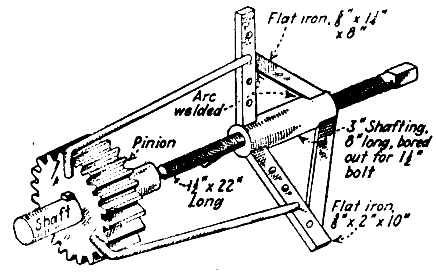
Three pieces of flat iron, ⅝ in. by 1¼ in. by 8 in., should be used as braces, with one end welded to the shafting and the other end to the horizontal 10-in. pieces. These braces must have their ends cut at an angle so that they will make a good fit and can be neatly welded.

Four holes 1 in. in diameter, for the puller hooks, should be drilled approximately 2 in. apart in the 10-in. arms.

The puller hooks consist of three pieces of ⅞-in. round iron, 22 in. long. Bend these at right angles, 2 in. from each end, so that one end can be hooked into the puller arm and the other end back of the pulley or gear to be removed from the shaft. Three sets of hooks should be made, so that on small gears or pulleys the set will be easier to handle. We use three sets of hooks of the following lengths: 8 in., 14 in., and 20 in. All of these are made of ⅞-in. round stock.

In operation the puller is placed against the gear or pulley to be removed, with the hooks inserted in the holes in the puller arms which will bring them as close as possible to the face of the pulley. The other ends of the hooks should be placed behind the gear or pulley. The 1½-in. bolt may then be screwed against the shaft with a wrench, thus forcing the gear or pulley off the shaft.

The puller described above was made for heavy service and weighs about 35 lb. Lighter material could be used, but the above specifications are recommended. As an example of what this puller can do fan spiders have been removed from a 2$\frac{15}{16}$-in. shaft when they fitted so tightly that we had to use a 36-in. wrench on the bolt, with a piece of 2-in. pipe slipped over the handle for extra leverage.



A gear or pulley is removed from its shaft by screwing in the threaded bolt.

If the bolt should become jammed and hard to move, run it through a threading machine. Also tap out the threads in the shafting, so as to keep the puller working freely at all times. Different hooks may readily be made to fit special gears or pulleys and can always be reused.

Chief Electrician, Shevlin Hixon Co., Bend, Ore. Wm. B. Cone.

Simple Method of Removing Fan Stators From Frames

QUITE often in removing stators from the drawn steel frames of 8-in. to 16-in. Westinghouse fans, considerable damage is done to the windings. The following simple procedure has been used with success in some shops, for the purpose of preventing such injury.

A 16-in. fan frame is 4 29/32 in. outside diameter. The core is 4¾ in. outside diameter which makes the thickness of the frame or shell approximately 5/32 in. When the end frame is removed from this size fan the core or laminations protrude approximately ¼ in. beyond the frame. Take a piece of 4½-in. iron pipe about 4 in. in length and bore it out to 4$\frac{49}{64}$ in. for a distance of 2¼ in. from the end. Face the end off straight while the pipe is in the lathe, using a tool that will leave a square shoulder at one end of the bore to prevent the core from jamming in the pipe.

Place the part of the core protruding from the frame into the pipe with the 5/64-in. shoulder resting on the end of the pipe that was faced off and while holding it in this position and keeping the fingers clear of the joint thus formed, strike the other end of the pipe on a block or solid bench with enough force to drive the core out of the motor frame or shell.

This same method can be applied to fans of other sizes, by using the proper size of pipe, and it will be found that the time and labor saved on the first few jobs will more than justify the expense of making these tools for the various sizes of fans.

Denver, Colo. John E. Holtman.

New Equipment

for plant operation and maintenance

Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these new devices which are designed to improve plant operation or reduce operating and maintenance costs.

Flux to Use in Gas Welding

A FLUX for oxyacetylene welding has been placed on the market by the Hoxite Co., Stamford, Conn. Tests, which have been conducted with the flux, are said to show good results on cast iron, malleable iron, aluminum, government bronze, Monel metal, brass, semi-steel and other metals.

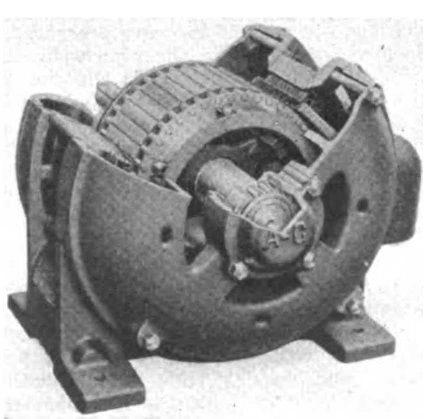
Some of the characteristics claimed for the flux are that it will not blow off the welding rod, that there is no frothing, and that it gives off no disagreeable fumes.

New Roller-Bearing Motor

AFTER two years of experimental and development work, the Allis-Chalmers Mfg. Co., Milwaukee, Wis., has placed on the market a complete line of 25- and 60-cycle squirrel-cage and slip-ring, induction motors in ratings up to 200 hp., equipped with Timken tapered roller bearings. These motors are being produced in addition to this company's well-known line of sleeve bearing motors. After designs of bearings and mountings had been made, a number of motors of various sizes were built and tested under actual operating conditions of belt, gear, chain and coupled drives, for a sufficient length of time to insure satisfactory service before the line of motors was put on the market.

The bearings are mounted in dust-proof, grease-tight enclosures and packed in grease so that further lubrication is required only at infrequent intervals. The bearings are mounted with a light press fit for both the cone and cup and do not require the use of a lock nut or other means of holding the races in place. This also facilitates the removal of the bearings.

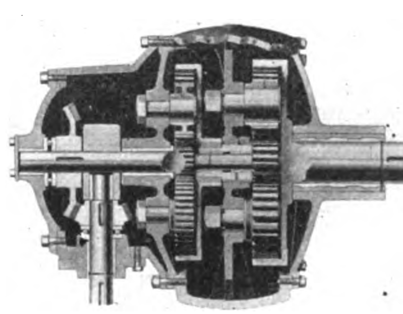
In addition to the bearings, special attention has been given to many other features of design in this line of motors.



The frame is made of steel with feet cast integral, so as to withstand shocks when used with crushers, grinders and other machinery. In applying the motors to Allis-Chalmers centrifugal pumps, severe conditions of moisture are often met; hence the coils are thoroughly insulated with waterproof varnish and baked. In saw mills, flour mills and cement mills, motors must operate in very dusty and dirty places. The openings in the housings and frames for ventilation are so placed in vertical planes, that falling objects cannot enter the motor.

Right-Angle Spur Reducers

THE new line of IXL right-angle drive spur reducers recently developed by Foote Bros. Gear & Machine Co., 215 N. Curtis St., Chicago, Ill., is designed to meet the requirements for



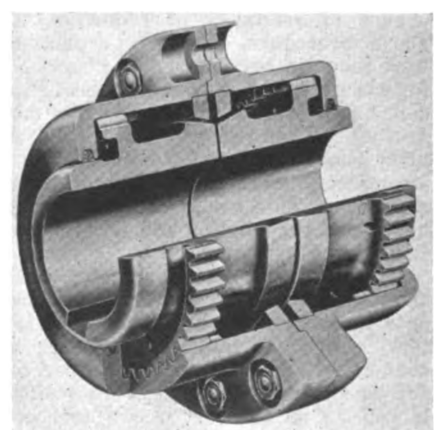
reduction gears that must operate in confined spaces where sufficient room is not available for the mounting of standard straight-line drive units and where it is necessary to change the direction of the power drive. This reducer is very similar in appearance to the standard, straight-line drive speed reducers except that the high-speed shaft projects at right-angles to the axis of the slow-speed shaft. The change in direction of the power drive is accomplished by means of bevel or miter gears mounted in the high-speed end. The secondary bevel or miter gears are mounted on the high-speed driving shaft which is concentric with the slow-speed shaft.

Except for the addition of the bevel gears in the high-speed end, the design of the machine is identical with the standard IXL non-planetary spur gear speed reducer. The high-speed pinion is integral with the high-speed shaft and delivers the power through three idler gears set at 120-deg. angles to a large rotating integral gear, which is securely fastened to the slow-speed shaft. The high-speed pinion, together with the idlers, internal gear and slow speed shaft, comprise the entire mechanism for a single reduction train which can be repeated to secure greater reduction ratios.

By changing the size of the pinion and internal gear and the relative size of the bevel gears in the high-speed end, it is said that almost any desired relation may be obtained between the speeds of the high-speed and low-speed shafts. The manufacturer produces these right-angle spur reducers in a large variety of standard sizes and reduction ratios, in horsepower capacities ranging up to 150 hp. and reduction ratios as high as 350 to 1.

Flexible Couplings for Shafts

THE accompanying illustration shows the construction of the Pool flexible coupling which is announced by The Poole Engineering and Machine Co., Baltimore, Md. This coupling consists of six parts: two hubs having an external gear on each meshing with internal gears in two sleeves which are bolted together and two aligning rings which are fitted in the two sleeves. The outer faces of the teeth on the hub are formed spherically, which, it is stated, provides a self-aligning bearing for the connecting sleeve, so that if the two shafts are out of alignment the sleeve assumes a neutral position with a lubricated bearing on the spherical surface of each shaft hub. This coupling is enclosed and so is protected from dust and dirt and is said to operate equally well in either direction on continuous or reversing service, and at high or low speed. All parts are made of high-carbon, forged steel and are interchangeable. Oil holes are provided in one side of the coupling flanges, into which oil should be poured until it runs around the shaft hub. When the coupling is running, the oil spreads out under the pressure so that the sleeve bearings and gear teeth operate in a bath of oil. Any good grade of lubricating oil can be used. These couplings have been designed, it is claimed, so that they are stronger than the connecting shaft and can be used on any shaft without consideration of a utility factor. Coupling ratings are given, however, which indicate the maximum horsepower the coupling will transmit under good service conditions, at 100 r.p.m. Factors are used for severe conditions.



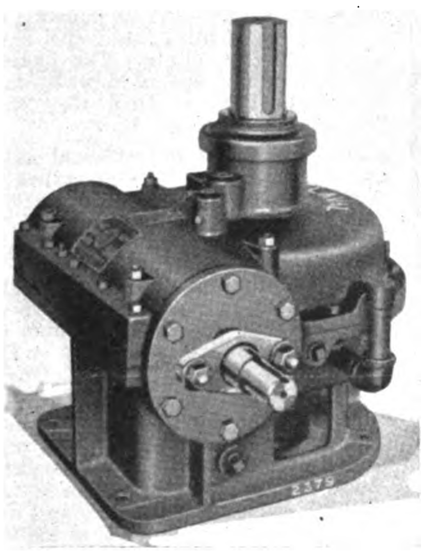
Machine Limit Switch

A MACHINE limit switch of compact design has been developed by the Monitor Controller Co., Baltimore, Md., with over-all maximum dimensions of 4 in. by 2⅛ in. by 2¼ in. This switch is designed to handle pilot circuits of d.c. or a.c. starters and controllers and, it is said, can be used as a limit switch to provide overtravel provision, as an interlock switch on machines, or for other similar purposes. It is constructed to be dust-tight. This switch is made in two types; one type has normally open contacts and the other has normally closed contacts. The standard type of construction has copper-to-copper contacts of large size which, it is stated, operate under heavy contact pressure. For special applications, these switches can be provided with silver contacts.

Worm Reduction Gear for Vertical Shaft Drives

THE accompanying illustration shows a worm reduction gear for vertical shaft drives recently developed by the DeLaval Steam Turbine Co., Trenton, N. J. The gear casing supports the worm bearings and also the lower bearing of the driven shaft. while the upper shaft bearing is held by the casing cover. The oil is carried at such a level that the worm and gear wheel dip into it, thus insuring ample lubrication. The lower wheel shaft bearing is always immersed in oil and has spiral oil grooves.

A small reciprocating oil pump is incorporated in the casing cover to provide oil for the upper wheel bearing and thrust plate. The plunger of the pump projects downward against a

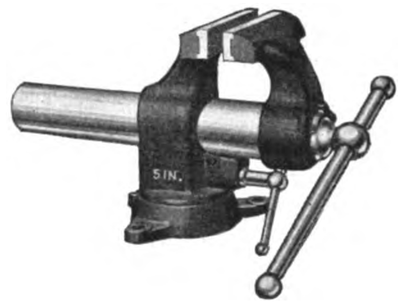


cam, which is located just outside of the thrust plate of the bearing. The rotation of the cam actuates the plunger which, by means of ball check valves, draws in oil through the suction pipe projecting from the under surface of the cover down into the oil in the casing. Suitable filling and drainage openings, together with a try-cock, provide for control of the oil level.

For larger, high-speed reductions, where it is not desirable to immerse the worm and wheel on account of fluid friction, a positive pressure oiling system is used to feed oil to all the bearings and to the worm threads and gear teeth at the contact points. A full line of these drives is made and drives can be furnished with the shaft extending either upward or downward.

Drop-Forged Bench Vise

A NEW line of drop-forged bench vises, one of which is shown in the accompanying illustration, has been brought out by The Fulton Drop Forging Company, 112 So. Main St., Canal Fulton, Ohio. These are sold under the

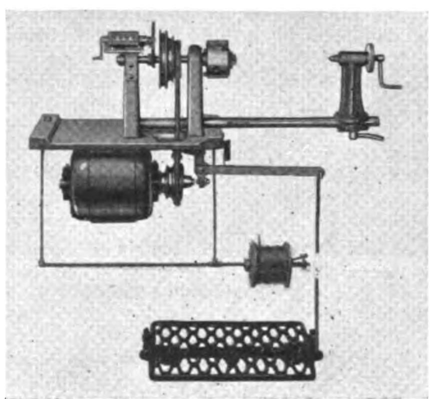


trade name of the Dropfo vise and are made with either a solid stationary base or with the Wedgelok swivel base. These vises are made entirely of interchangeable drop-forgings in four sizes: 3 in., 4 in., 5 in. regular and 5 in. heavy duty, and it is stated that the various sizes of these vises weigh less than the corresponding sizes of ordinary vises. The jaw plates are knurled as they are forged and are doweled on.

The swivel type is so constructed that tightening the jaws automatically tightens the base, or it may be tightened independently where it is desired to use it as a stationary vise.

Small-Coil Winding Machines

ANNOUNCEMENT is made of the production of a small bench type coil winding machine for winding small solenoids, by the Armature Coil Equipment Co., 2415 Forestdale, Ave., Cleveland, Ohio. The machine, which is shown in the accompanying illustration, is operated by a ¼-hp., 1,800- or 1,200-r.p.m., ball-bearing motor. The winding spindle in the headstock is also provided with ball bearings. Control



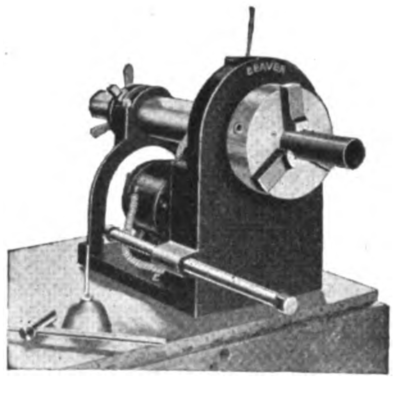
over starting and stopping is through the foot treadle and clutch in connection with a brake. A three-jaw, 3-in. universal chuck is provided for holding any job or fixture. A four-wheel Veeder counter of 10,000 turn capacity which resets to zero with one turn of the crank, is attached. The bracket for receiving supply spools has a tension device working against the side of the spool through a spring tension which can be adjusted quickly to suit the needs of any particular job.

Magnetic Switch for High Frequencies

A NEW enclosed switch, bearing the designation CR-7006-S-3, has been placed on the market by the General Electric Co., Schenectady, N. Y. This switch was designed for wood-working applications where frequencies higher than 100 cycles are necessary. A special coil and magnet frame construction is used, without increasing the over-all dimensions of the switch. The rating of the switch varies according to the frequency of the circuit on which it is used; at 120 cycles, it will be operated on 220 volts; at 150 cycles, on 275 volts; at 180 cycles, 330 volts, and so on for any other corresponding intermediate voltage and frequency. The switch is built in two-pole form to conserve space and provide one disconnecting switch for all motors.

Power-Driven Pipe Tool

ANNOUNCEMENT is made of a new power-driven pipe threading and cutting tool by The Borden Co., Warren, Ohio. This is known as the No. 44 Beaver power drive, in which the pipe revolves while the tools are stationary. The unit weighs 230 lb., is portable, and is operated by a ½-hp., heavy-duty motor. It is stated that any



type of pipe threading tool may be used in connection with this outfit, to handle pipe ranging from ¼ in. to 2 in. diameter, inclusive. By means of a universal shaft this unit may be used to drive a No. 41 Beaver die stock for cutting threads on 2½-in. to 4-in. pipe, or with a No. 61 Beaver die stock to cut threads on 2½-in. to 6-in. pipe. The socket end of the shaft has a standard opening so that it will fit into the square of the pinion on any make of geared die stock.

Trade Literature

you should know about

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Stationary Tachometer—Bulletin 1080 describes a new Jagabi Type B stationary tachometer which operates on a centrifugal principle, runs in either direction, and may be used for the continuous indication of speed.—James G. Biddle, 1211-13 Arch St., Philadelphia, Pa.

Small Motors—A circular, Form 308, illustrates and describes the principal features of this company's single-phase, ⅛- to 5-hp., repulsion-induction motors, direct-current motors of ⅛ to 1½ hp., and polyphase (two- or three-phase) motors of ⅛ to 7½ hp.—Master Electric Co., Linden and Master Aves., Dayton, Ohio.

Automatic Switching Equipment—Circular 67716-A, Class 17, describes automatic switching equipment for indoor a.c., reclosing feeder service from 440 to 7,500 volts, lists its advantages, describes the mechanism and principle of operation.—General Electric Co., Schenectady, N. Y.

Cable Splicer—A circular describes a method of splicing cable conductors by the use of the Canton, a special cable splicing clamp around the overlapped ends. With this clamp, it is claimed that a 300,000 circ. mil cable can be spliced in 10 min. with 4 in. of overlapped ends.—The American Mine Door Co., Canton, Ohio.

Ball-Bearing Motors—A circular describes the Marble-Card ball-bearing d.c. motors and generators in sizes from ½ to 75 hp.—Marble-Card Electric Co., Gladstone, Mich.

Window Cleaning Solution—A circular describes Sunburst, which is claimed to be a harmless liquid which will quickly remove deposits of carbon, grime or rust from factory windows and skylights without injuring the paint, putty or frames. — The Guerson-Stewart Corp., E. 76th and W. & L. E. R. R., Cleveland, Ohio.

Graphic Pressure Recorders—Bulletin 625 describes the use of graphic pressure recorders, their construction and use.—The Esterline-Angus Co., Indianapolis, Ind.

Grease—A circular describes Kent grease which is recommended for use on gears and bearings in connection with a grease gun system of pressure lubrication.—Kent Lubricating Co., Colby-Abbott Bldg., Milwaukee, Wis.

Fusible Primary Cutout—Circular GEA-99 describes and illustrates the expulsion Type E, Form A, fusible primary cutout rated at 30 amp., which is porcelain housed and suitable for use on circuits carrying up to 7,500 volts.—General Electric Co., Schenectady, N. Y.

Water Softener—Bulletin 509 describes the Zeolite water softener which provides water without hardness by the pressure filter method. — Graver Corp., East Chicago, Ind.

Belt Cutter—Circulars describe the K-D belt cutter which may be adjusted to cut or trim down belts to any width desired.—The Klinger-Dills Co., 129 N. Jefferson St., Dayton, Ohio.

Automatic Motor Starters—Bulletin 1016-B describes the E. C. & M. automatic motor starters for non-reversing, direct-current motors. These are made in two general designs according to the manner of mounting the apparatus, and the rating.—The Electric Controller & Mfg. Co., Cleveland, Ohio.

Hand-Operated Air Hammer — Circulars describe the Maxson air hammer which is operated by a hand crank, and is claimed to be able to deliver from 750 to 1,500 effective blows per minute. This hammer does not require any electric or air connection and, it is said, will bite ¼-in. to 1½-in. holes through concrete at the rate of 1 in. per min. It may also be used for rivet driving and with chipping tools.—Maxson Sales Co., Monadnock Bldg., Chicago, Ill.

Squirrel-Cage Motors—Circular GEA-6 describes the 500 Series of general-purpose, continuous-duty, constant-speed, squirrel-cage motors of 15 to 150 hp. at 220, 440, 550 and 2,200 volts, and the types of control equipment used.—General Electric Company, Schenectady, N. Y.

Insulation Resistance Testing—Bulletin 130 describes the Model D Megohmer, Bulletin 125 the Junior Megohmer, and Bulletin 135 the 2-in-1 Megohmer. Each bulletin shows the application of these in making insulation resistance tests.—Herman H. Sticht & Co., 21 Park Row, New York City.

Ventilation Equipment—Circulars describe and show applications of the Norblo exhaust fans which are designed to meet varying conditions and hard service.—The Northam Blower Co., W. 65th St. and Wheeling & Lake Erie R. R., Cleveland, Ohio.

Adjustable Lighting Fixtures—Catalog 3 describes the Axcess system of adjustable lighting fixtures which may be applied to benches, machines or cabinets to adjust the light within convenient range of the work.—Samson Axcess System, Inc., Lynn, Mass.

Condulets—Folder 27 and Bulletin 2076 describe and give dimensions of the screw-cover, junction condulets which are made in 2½-in. and 3½-in. diameters.—The Crouse-Hinds Co., Syracuse, N. Y.

Mechanism-Operated Multi-Pole Switches—Bulletin 116 describes the 8800 Type, mechanism-operated, multipole switch designed for horizontal mounting and built for all standard voltages from 15 to 132 kilovolts and amperages of 300, 600 and 800. This switch is designed for line sectionalizing, substation switching, or for any condition where a ruggedly-built, easy-operating switch is required for horizontal mounting.—Electrical Engineers Equipment Co., 710 W. Madison St., Chicago, Ill.

Ball Bearings—Price lists and descriptive matter cover the Gurney deep-groove, radial and double-row ball bearings. — Marlin-Rockwell Corp., 402 Chandler St., Jamestown, N. Y.

Valves—A circular describes Valve No. 7, a many-purpose valve with a quickly renewable disk.—Crane Co., 836 S. Michigan Ave., Chicago.

Small Motors—Folders describe the Janette special motors rated from 1/20 to 1/3 hp. for a.c. and d.c. current. Special attention is given to the bearings and the method of lubrication.—Janette Manufacturing Co., 556-558 W. Monroe St., Chicago, Ill.

Transformer Data—No. 5 of a series of monthly bulletins contains four interesting data sheets on the connection of transformers.—Moloney Electric Co., St. Louis, Mo.

Switchboard Instruments—Circular GEA-25 describes round-pattern, switchboard instruments, 7½ in. in diameter, for alternating or direct-current service. Circular 66016-A describes horizontal, edgewise alternating or direct-current switchboard service instruments.—General Electric Co., Schenectady, N. Y.

Socket Wrenches—Catalog B describes the Snap-on interchangeable socket wrenches and attachments with square or hexagonal sockets for use on automobiles or industrial work. Giant socket sets are provided for the larger sizes of nuts.—Motor Tool Specialty Co., 14 E. Jackson Blvd., Chicago, Ill.

Expansion Shells—A circular describes the Phillips self-drilling, expansion shells for attaching pipe hangers and other similar purposes. One end of the shell is arranged as a drill, expands while drilling, and the shell remains in the ceiling. The hanger or other equipment is screwed into the shell.—Phillips Drill Co., 1537 Cortland St., Chicago, Ill.

Counters—A series of sectional catalogs describe the numerous types of small counters for counting revolutions or strokes, elevator mileage recorders, special counters for textile machinery which record operation in yards or other units, and magnetic counters which may be placed at some distance from the machine on which the record is taken. — The Veeder Mfg. Co., Hartford, Conn.

Glare Prevention—A circular describes "Blu-EE" which is a special preparation to place on window glass, particularly on skylights and west windows, to prevent eyestrain it is claimed, by eliminating shadows and glare. It is also claimed that the use of this material will help to keep the plant cooler in summer.—Park Chemical Co., 3818 Edwards Road, Cincinnati, Ohio.

Carbon Brushes—A catalog describes and lists Carenco carbon brushes for motors and generators, gives instructions for ordering and descriptions of the various grades, with illustrations of the different types and their applications.—Carbon Engineering Co., 1700 8th Ave., Milwaukee, Wis.

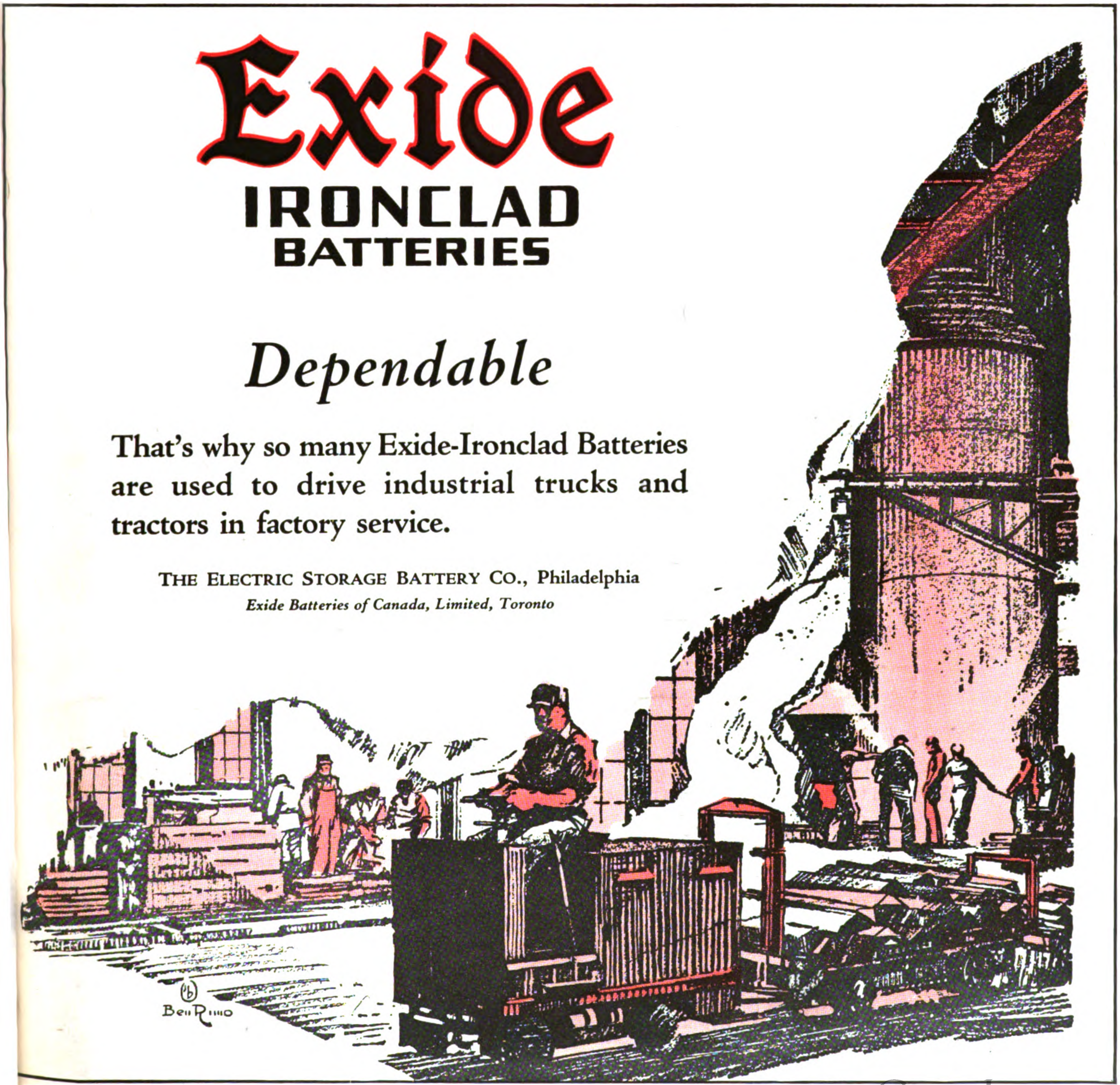
INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

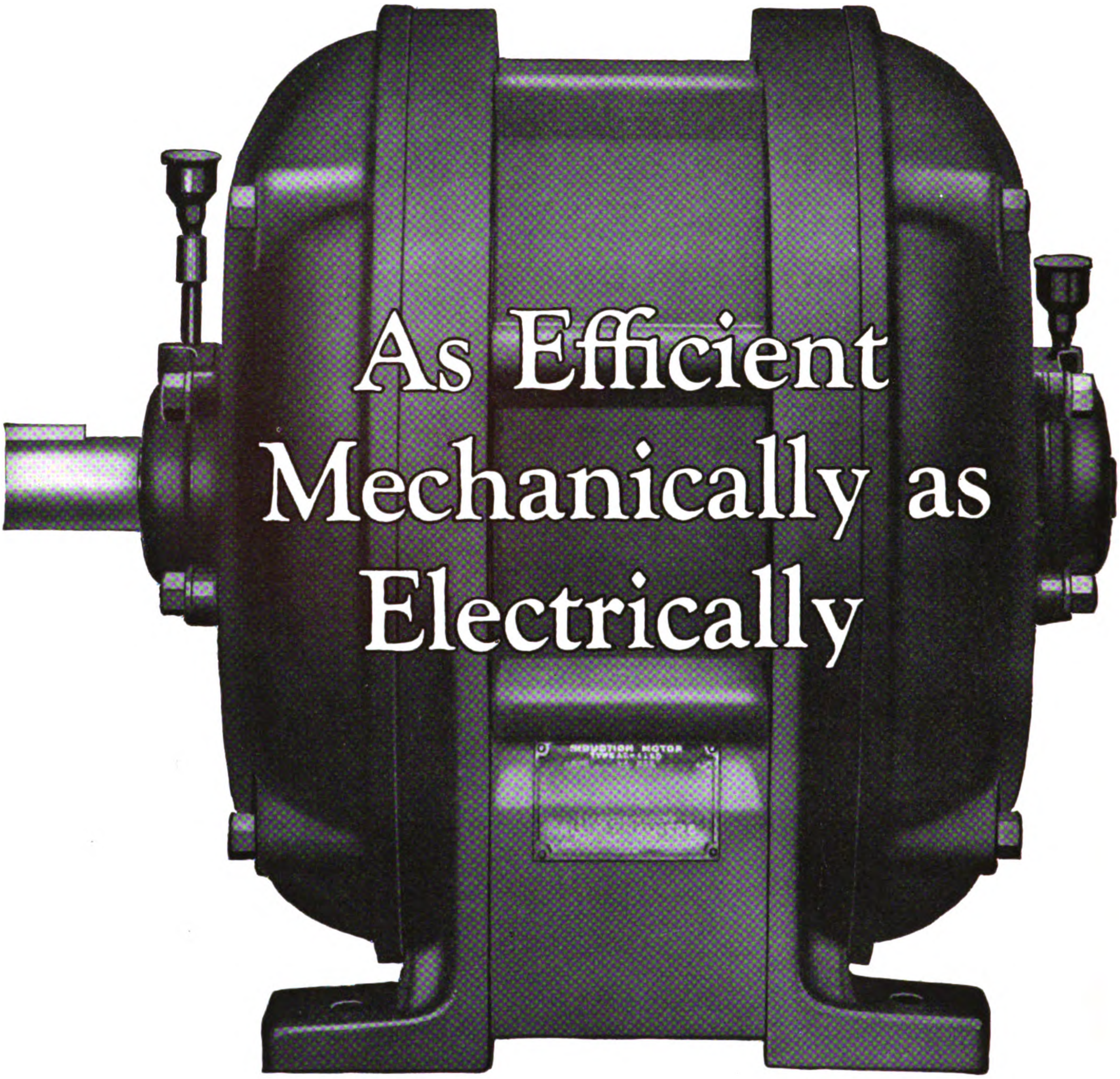
Founded 1882 as
The Electrical Review

February, 1926

McGraw-Hill Co., Inc.
Chicago, Ill.



MAINTENANCE AND REPAIR ISSUE



High efficiency over an exceptionally wide range has always been an outstanding characteristic of Allis-Chalmers electric motors. Excellent design, consistently developed, and the use of carefully chosen materials have resulted in matchless operating economy and endurance in all types of Allis-Chalmers motors.

Allis-Chalmers mechanical superiorities are emphasized in the Type "AR" induction motor equipped with Timken Tapered Roller Bearings. Their greater load area for space occupied permits shorter, more rigid shafts. Their freedom from friction makes it unnecessary to lubricate more than a few times yearly at the very most. Their extreme resistance to thrust, shock and every form of wear maintains the gap for the life of the motor.

In bearings, as in frames, cages, windings, fan, and every other factor of design and construction, each type of Allis-Chalmers motor represents the higher value made possible by the scope of Allis-Chalmers activities, and by the wide acceptance of Allis-Chalmers products. Send for Motor Bulletin 1132.

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ALLIS-CHALMERS MOTORS

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

McGraw-Hill Company, Inc.
James H. McGraw, *President*
James H. McGraw, Jr., *Vice-Pres.-Treas.*

G. A. Van Brunt, *Managing Editor*

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Standards of Design and Performance

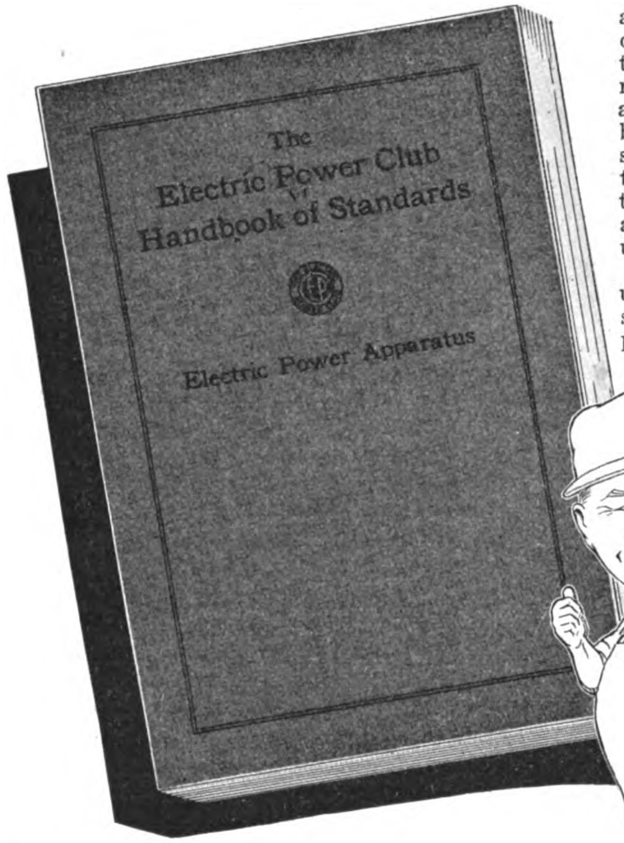
with some pointers for buyers who want to get their money's worth

WHEN you go into a plant these days and talk with the engineers, superintendents and those who act as company purchasing agents, at some time in the conversation the word "standardization" will be used, and in almost every such conversation it will have from two to ten different interpretations.

The impression seems to be current that standardization is the offspring of efficiency, which some years ago was an over-worked word in the language of those who are now known as efficiency experts. Be that as it may, the fact is that "efficiency" and "standardization" are merely words in the minds and results of those who simply buy equipment of one make and put it to work without a thorough analysis of the job to be done and the results that are to be secured in terms of cost, time factors, quality and improvements in keeping with the progress of the art of which the job is a part.

Henry Ford for more than 16 years has made a road vehicle in which nearly every part today is interchangeable with every part of the original model. But today there is hardly a single part that is made of the same material or made in the same way as the original parts. This is a standard vehicle in which the construction has been standardized, but in making this standard model possible, nothing in production methods has been standardized. On the contrary, the process of production has been one of continual change in materials, machinery, and methods, so as to improve the result and bring about better quality and durability.

Today when a plant superintendent thinks he is standardizing by buying all of one make of motor, starter, instrument or any other electrical tool used in production operations, he is simply fooling himself and thinking more about the price he can get on a quantity purchase of a single make



rather than about the job that he is responsible for and his need for equipment that will place him in a position to secure the best results at the lowest operating cost. First cost in any investment in plant equipment is by no means the total cost, and many a low first cost has turned out in years of service to be an excessive total cost. In the studies that have shown this to be true, durability, reliability and quality of design and materials used have been the factors that have told the tale.

The thing that plant superintendents should study these days about the production tools they buy, in addition to their use, is standards of design and construction and in these matters as regards electrical devices there is no excuse for being in the dark. On this page I am showing the cover of a publication that in almost its present form is more than ten years old and now contains 245 pages. This volume, *The Electric Power Club Handbook of Standards*, gives details of design standards for practically all electric power apparatus used in an industrial plant as made by 81 leading manufacturers. In this group, for instance, there are at least 32 that make motors, and each and every one builds motors to these standards. One motor is better than another, therefore, not because of the design standard alone, but in the quality of materials, workmanship, and ability to stand up in service.

Price alone may be used to select a design standard, but price alone can never be used with safety to select a service standard and here is where good judgement and much practical experience show up the difference between a poor buyer and a good one. Today the good buyer will not purchase an electrical or mechanical device until he has applied a rigid set of tests. It is in making these tests that standards of design should be known, so that the tests will be fair to the device.

If you want to be one of these good buyers, it will pay you to have a copy of this handbook. It can be purchased from the Secretary of the Electric Power Club, B. F. Keith Bldg., Cleveland, Ohio, at a cost of only one dollar. My advice is to secure a copy and study it—then pay for reliability and performance of equipment, not for so many pounds of copper and iron and a nameplate rating.

Practical Pete

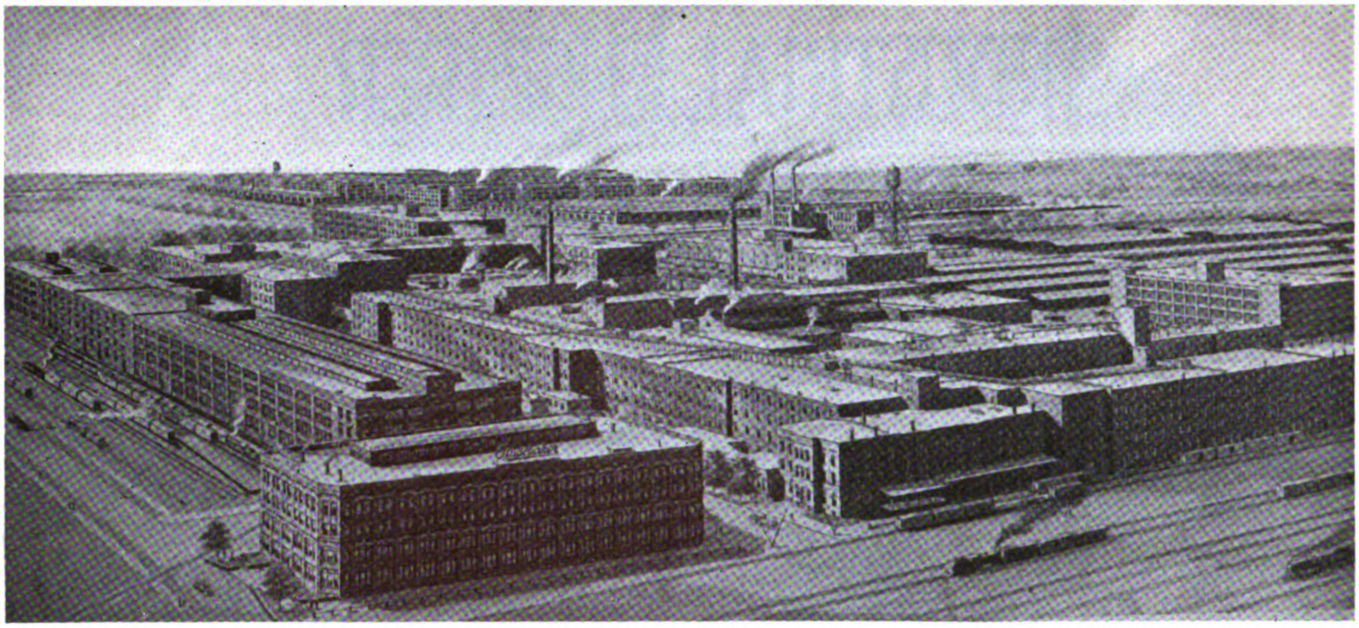


Fig. 1—Keeping the electrical equipment in operating condition in a plant of this size calls for a well-organized Electrical Department.

This illustration shows the South Bend (Ind.) properties of The Studebaker Corporation. In the foreground is Plant No. 1, while in the center background is Plant No. 2. The latter is the newer and by far the larger plant. The two plants together cover an area of more than 191 acres.

Handling Maintenance and Repairs on 4,000 Motors

and also on 700 portable electric tools, 28 battery tractors, and 35 cranes, with details of how the work is organized and responsibility delegated

By WILLIAM RASSMUSSEN

Chief Electrician, The Studebaker Corporation, South Bend, Indiana.

HIGH quality of product must not only be provided for in the design, but also must be built in during production. To enable a factory to produce a high-quality product, the equipment must be maintained in perfect order. As one of our most prominent automobile manufacturers puts it, "The first duty of management is to keep the tools in shape. By the tools is meant the entire plant and everything pertaining to it." This requires an organization that understands the requirements of the equipment, how it should be installed to obtain the most satisfactory results, what routine inspection and maintenance is required, and how it may be repaired in case of breakdown or failure.

To obtain an idea of the scope of operations of the electrical maintenance and repair organization of the Studebaker plants at South Bend, Ind., let us consider the extent and character of these plants.

There are two plants at South Bend, which together cover an area of 191 acres. A bird's-eye view of the two plants is shown in Fig. 1. Plant No. 1 makes springs, small forgings and stampings, windshields and all the types of bodies used on Studebaker cars. Plant No. 2 is the larger and consists of a forge shop, stamping plant, iron foundry, machine shop, stores and assembly building, final car assembly building, car storage building, shipping building and power house. The diverse character of the different operations carried on in these plants is readily apparent.

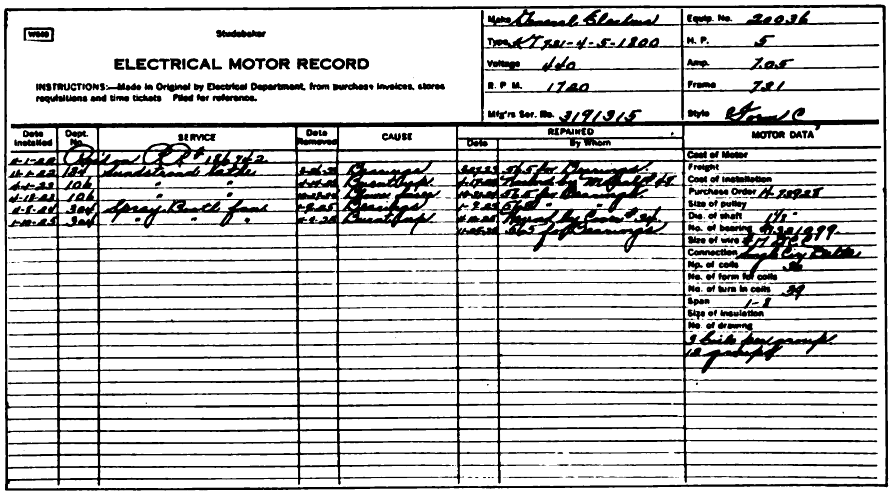
In the two plants there are over 4,000 motors ranging in size from 1/8 to 700 hp., together with about 700 electric portable hand tools. To furnish the power required by this scale of operation, there is a power house with turbo-generator capacity of 16,000 kw. Power is generated at 2,300 volts, three phase, 60 cycles and carried underground by means of lead-covered cables to substations near the various load centers of the plant, where it is transformed to 440 volts a. c. and converted by motor-generator sets to 220/110 volts d. c. for power, and stepped down to 220/110 volts, a. c. for lighting. The total connected power load of the two plants is 28,366 kw., and the total connected lighting load is 4,050 kw.; this gives a total connected load of 32,416 kw. The maximum demand is about 14,000 kw. and the average power consumption per month is about 4,000,000 kw.-hr.

To operate, maintain and repair the electrical equipment that has just been briefly outlined requires an Electrical Department consisting of a force of 140 to 160 men, under the supervision of the Chief Electrician. A chart of the organization of the Electrical Department is shown in Fig. 6. As will be seen, there are two Assistant Chief Electricians, one in charge of each plant, both of whom report to the Chief Electrician. Under each of these men are straw bosses who are in direct charge of the various divisions of the department. Let us consider the duties and responsibilities each of these in turn.

Maintenance Electricians.—In this division there are 18 men in Plant No. 2 and 9 men in Plant No. 1. In Plant No. 2 these men are assigned as follows: enameling dept., one man; foundry, four men; forging department, two men; machine shops, three men; sub-assembly, three men; stamping department,

one man; and general, four men. These men are located as shown so as to be close to the trouble calls that originate in their departments.

Instead of having lengthy records and reports to check off as to what he has done or should do, the responsibility of keeping his own department running is placed squarely up to each man. This gives each man a feeling of pride and an incentive to make a good showing. A check on their work is made by means of the *Call Record* which is shown at *F* of Fig. 4. Whenever electrical trouble occurs, a telephone call is sent to the maintenance man in charge of that department. The time that the call was received and the location of the faulty machine are entered on the form. The maintenance man going out on this job, enters his name and the time he left in the proper columns. When he returns he enters the time of his return, together with any remarks that may be necessary. One of these forms is made out each day for every group of maintenance men serving a given department. These records go to the Assistant Chief Electrician every night, so that he has a complete record of all trouble calls, how soon they were answered, and how soon the trouble was corrected. Inasmuch as each maintenance man also makes a note on this same form each time that he goes on an inspection trip, naming the installation inspected, a complete record of the activities of all of the maintenance men is available from this form. The form is very simple, involving a minimum of paper work on the part of the maintenance man, which is a decided asset.


W600

Studebaker

ELECTRICAL MOTOR RECORD

INSTRUCTIONS:—Made in Original by Electrical Department, from purchase invoices, stores requisitions and time tickets. Filed for reference.

Make
Type
Voltage
R. P. M. 1720
Mfg'rs Ser. No. 3191315
Equip. No. 20036
H. P. 5
Amp. 7.05
Frame 721
Style

Date Installed	Dept. No.	SERVICE	Date Removed	CAUSE	REPAIRED Date	REPAIRED By Whom

MOTOR DATA
Cost of Motor
Freight
Cost of Installation
Purchase Order
Size of pulley
Dia. of shaft
No. of bearing
Size of wire
Connection
No. of coils
No. of form for coils
No. of turn in coils
Span 1-8
Size of insulation
No. of drawing

Fig. 2—This card is the basis of the motor record system.

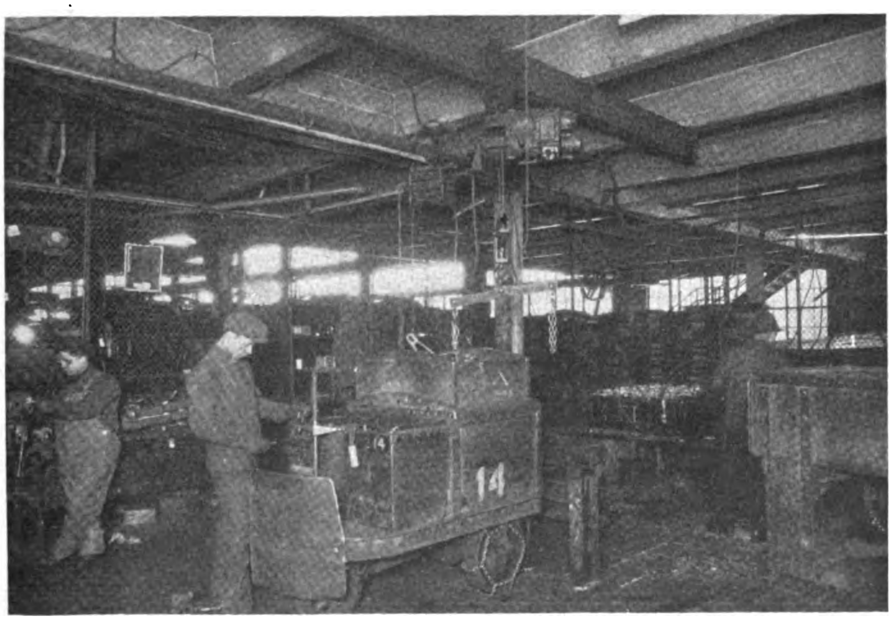
On it are placed the complete nameplate data of the motor, the equipment number that is assigned to it, motor repair data, and a record of its service, including cause of failures. There is also space for giving the nature of the repairs, together with the name of the man or department that made them.

When there are no trouble calls on hand, the men are expected to make regular rounds of the equipment under their care, inspecting bearings, commutation, heating and general operation of the motors, control and other electrical equipment.

It will be noticed that in the assignment of men, four were marked general. Three of these are crane inspectors and repair men. They spend their entire time inspecting, maintaining, and repairing the 35 cab controlled cranes and 80 electric hoists varying in capacity from ¼ to 3 tons, all of which are located throughout the plant. Not only is the Electrical Department responsible for the electrical equipment of the cranes, but also it does all of the mechanical repair work on them that is required.

Fig. 3—Repair shop for the electric industrial trucks and tractors.

In this shop are made all mechanical and electrical repairs and inspections that may be required on the fleet of 28 trucks.



A more detailed inspection report is required of the crane inspectors. The form used is shown at *G* of Fig. 4. The vertical columns are for the individual cranes inspected and on the horizontal lines are listed the parts inspected.

Daily inspection of all equipment is not attempted, because the duty is not so severe as to warrant having a gang of maintenance electricians large enough to do this. At week ends, overhauling and more thorough inspections are conducted.

Electric Repair Shop.—There are two electric repair shops, one in Plant No. 1 and the other in Plant No. 2. The former is devoted almost entirely to rewinding, repairing and otherwise maintaining the electric portable tools. All manner of repairs are made to these tools; in fact, they are rebuilt from stock parts whenever necessary. Armatures having form-wound coils are specified when the tools are purchased. This type of winding has been found more satisfactory for the service to which they are subjected in these plants; also they are much easier to rewind.

Three men are required in this shop for handling this work. A corner of the repair shop is shown in Fig. 5. A small precision lathe for turning commutators and doing what other lathe work may be necessary on the portable tools, together with a small press for pushing out armature shafts, are the main pieces of equipment required. Inasmuch as no machine winding is used and the form-wound coils are

purchased, no coil winding equipment is required for this particular class of work.

The main electric repair shop is in Plant No. 2. In this shop all other motor repair as well as control repair work is conducted. Aside from the general run of electric repair work, about 500 armatures are rewound per year. Five men are continuously employed in this shop.

For winding and forming coils, a Segur coil winder and a Segur coil former are provided, as shown in Fig. 10. All mush coils are wound in the shop and, in addition, any other coils that might be required in an emergency. A large stock of coils is carried in the electrical storeroom to meet the usual rewinding demand.

Stators are stripped by burning out the old winding. This is a rather rough method, but it serves

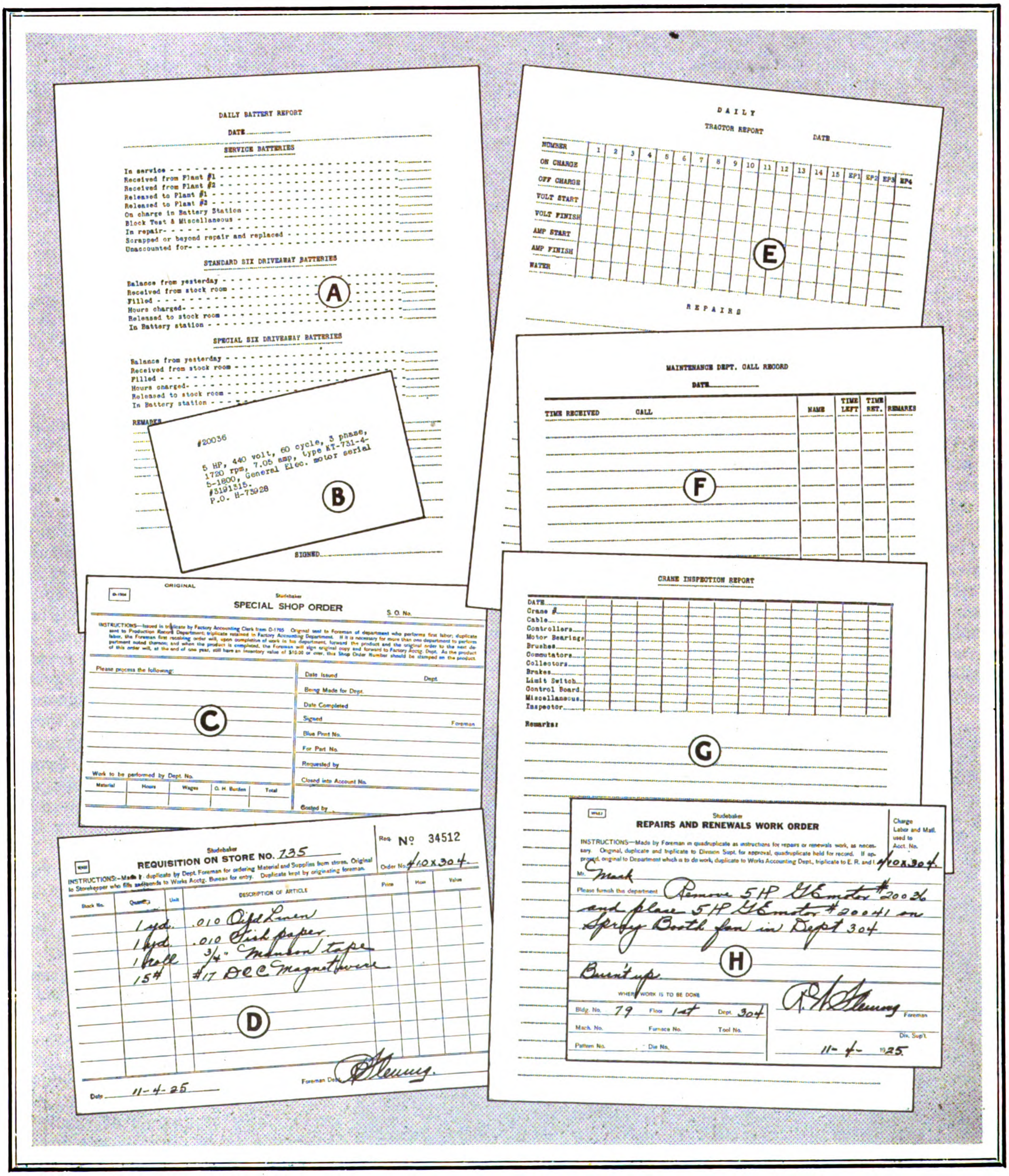


Fig. 4—Records that keep the department head informed as to the progress of work being done.

At *A* is shown the daily report of the battery maintenance section. *B* is the record of equipment numbers assigned to the motors. *C* is the form used for authorizing all new installation work. The form shown at *H* is similar except that it is issued for repairs and renewals. Material is taken from the storeroom on the form shown at *D*. *E* is the daily report of the tractor maintenance section. *F* is the report of all calls received by the general maintenance men. *G* is the crane inspector's report showing the operating condition of the cranes.

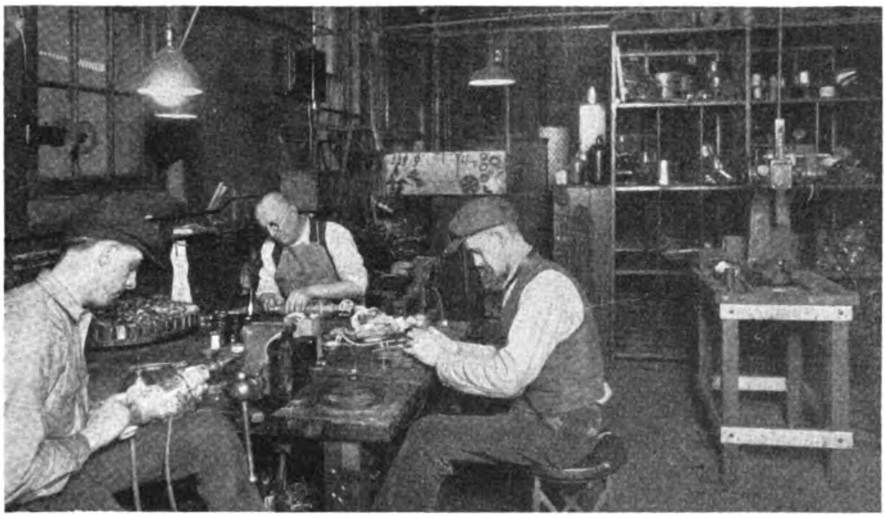


Fig. 5—This is a corner of the shop where all repairs required by 700 portable electric tools are made.

At the right is a small press for pressing out armature shafts. In the center background is shown a small precision lathe used for turning commutators and doing any other machine work required in making repairs on the tools. Note the circular compartment drawer for holding the many small repair parts, shown at the left on the workbench.

the purpose. A corner of the shop where the armatures and stators are wound is shown in Fig. 8. At the rear is the storage rack for stock and repaired armatures.

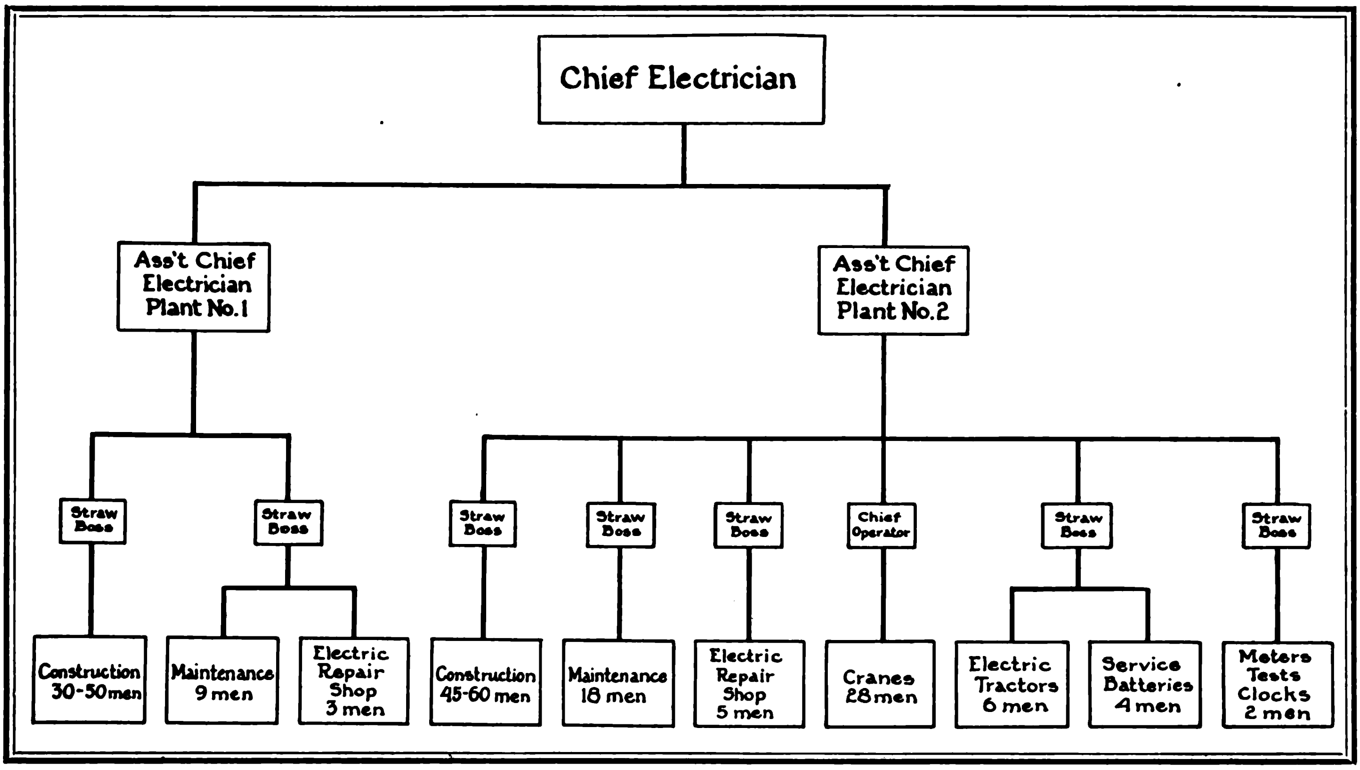
After the machines are wound they are tested for shorts and grounds. They are then preheated in the baking oven shown in Fig. 10 for 12 to 16 hr. This baking oven is equipped with a pyrometer which automatically holds the temperature at 220 deg. F. The stators or armatures, as the case may be, are then removed and dipped while hot in amber baking varnish. The arrangements for doing this are very convenient. The machines are on a small car while in the oven. This car is pulled out and the machines lifted out of the car by a small chain block which is carried on a light trolley travelling on an I-beam. By means of this small monorail hoist, the machine is carried directly back from the oven to the dipping tanks, which are just to the right of the field of view in Fig. 10. These tanks are cubical in shape, measuring about 4 ft. each way, and are arranged with hinged covers to prevent undue evaporation of the baking varnish solvent. One tank contains amber baking varnish while the other contains black elastic baking varnish. By means of the hoist the machine is held over the tank to drain and is then placed on the car and into the oven and baked for 12 hr. It is then removed from the oven and dipped in black elastic baking varnish and baked for 16 hr.

Many industrial plants have some atmospheric conditions that are the cause of a majority of the motor failures. In this plant the troublesome condition is the dust from grey iron castings in the machine shops where work is done on this product. This dust is very fine and causes trouble similar to that experienced from carbon, coal, and coke dust in steel mills and coke plants. Trouble from this source has been greatly reduced by the use of a plastic compound which is put over all exposed portions of the windings.

After a motor has been rewound, it is given a running test at no-load.

The foundation of the system of keeping track of the 4,000 motors in this plant is the *Electrical Motor Record* card shown in Fig. 2. This record is kept by the repair shop foreman and is located in his office. At the time of requisitioning or ordering a motor from a motor

Fig. 6—How responsibility for the proper functioning of an electrical department is divided among an organization of 160 men, is shown in this organization chart.



work from the machines, which may change the motor loading. Inasmuch as the larger number of motors are of the squirrel-cage type, it is essential that they be loaded to somewhere near their rated capacity so as to obtain as high power factor as possible. In this connection it might be said that the plant power factor averages 75 per cent, which is very good, considering the large induction motor load carried.

One man devotes all of his time to making tests. He has the following test equipment at his disposal: four voltmeters of various ranges, some for a. c. and the others for d. c. work; five ammeters of various ranges, some for a. c. and others for d. c.; a complete set of instrument transformers and ammeter shunts; one Megger testing set; one rotating standard watt-hour meter for checking the various watt-hour meters around the plant; one foot-candle meter; one Wheatstone bridge; one graphic wattmeter; one graphic voltmeter; and one graphic power factor meter.

In the main, tests are made to determine loading and power factor. For this work the Esterline-Angus graphic instruments mentioned previously give a chart record that may be kept for comparison with later developments. Whenever any trouble develops that the maintenance man cannot correct he puts in a call for the tester. If the test shows that a motor of different rating is required, a motor of the correct rating is installed and a duplicate test is made to check the installation.

Frequent tests are required in some departments because of the possibility of increased load due to changes in the production equipment. This is particularly true in the machine shop. Practically all of the motors in this department drive lineshafts. The control for these motors is grouped at four different locations. At each location is installed a distribution switchboard such as is shown in Fig. 11. This board controls 30 motors. As may be seen, the switches are grouped in pairs, one being the starting switch and the other the running switch. These switches are served by two sets of buses, the running switches being fed from a 440-volt, alternating-current supply, while the starting switches are fed from an auto-transformer which supplies the correct starting voltage for the motors. With this arrangement only one auto-transformer is required for starting duty on the 30 motors.

An Esterline-Angus graphic wattmeter is located at each end of the switchboard and is so connected with the double bus system that it may be readily switched in so as to measure the load on any one of the 30 motors. Tests are made upon any motor that gives cause for suspicion and routine tests are made on all motors on this board at least once every three months.

The tester has one man whom he may call upon for aid when he has more test work than he can handle. Ordinarily this man takes care of all the time clocks which are scattered throughout the plant. These time clocks, which are used for stamping on each workman's time card the time of beginning and stopping work, must be checked, every day to insure accuracy.

Construction. — The Studebaker Corporation has undergone tremendous expansion since its incorporation in 1911. In fact its investment in plants and property in 1923 was over five times as great as it was in 1911. During the period from 1919 to 1923, the amount invested in plants and property doubled.

With expansion taking place at this rate it is necessary to have an electrical construction department that is organized to carry on the installation of electrical equipment at a rapid rate. Two construction gangs are used for this work, the one in Plant No. 2 varying from 45 to 60 men, while the one in Plant No. 1 ranges from 30 to 50 men. Each gang is under a straw boss. The men in each gang are split up into small groups of two to six men, each group being under a gang leader. It is the duty of this section of the Electrical Department to do all of the installation of electrical equipment required by any changes, alterations and additions that are constantly being made in the plant. This not only involves the installation of motors and control, but also includes all wiring and conduit work, lighting, substation and transformer installation, wiring of cranes, feeders, battery charging stations and the like.

Electrical Equipment. — A word concerning the electrical equipment used might be of interest. Although there are 440 volts, three phase, a. c., 220/110 volts, single-phase, a. c., and 220/110 volts, d. c., available at almost all parts of the plant, the bulk of the motors are 440-volt, squirrel-cage induction motors. Individual drive is used in many cases, but the larger share of the drives are to lineshafts.

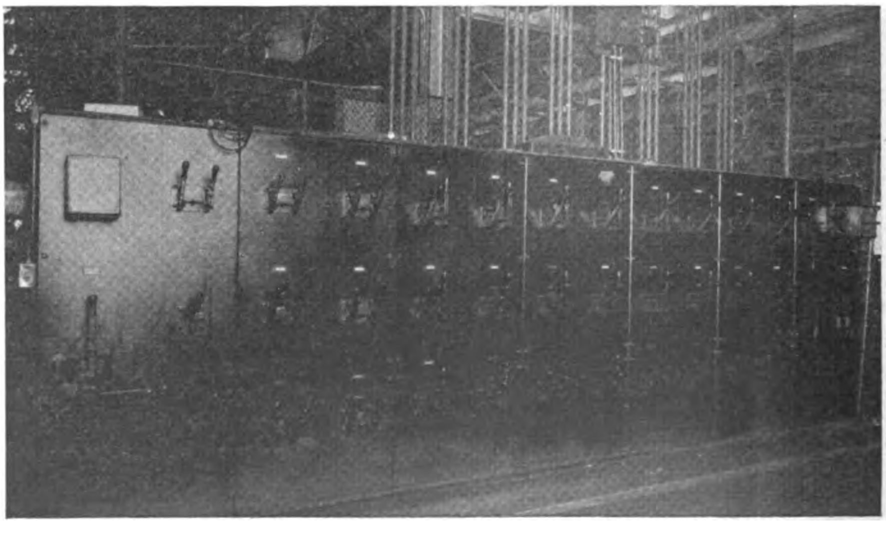
With 4,000 motors in the plant it is essential that they be standardized as to size and speed as much as possible. For lineshaft drives, motors of 30 hp. and above are limited to 900 r.p.m. speed; between 10 and 30 hp., a speed of 1,200 r.p.m. is standard; below this rating, speeds of 1,200 and 1,800 r.p.m. are used. A 50-hp. motor is the largest motor used on a lineshaft—if the lineshaft requires a larger motor, two motors are used and the load divided between two lineshafts instead of one.

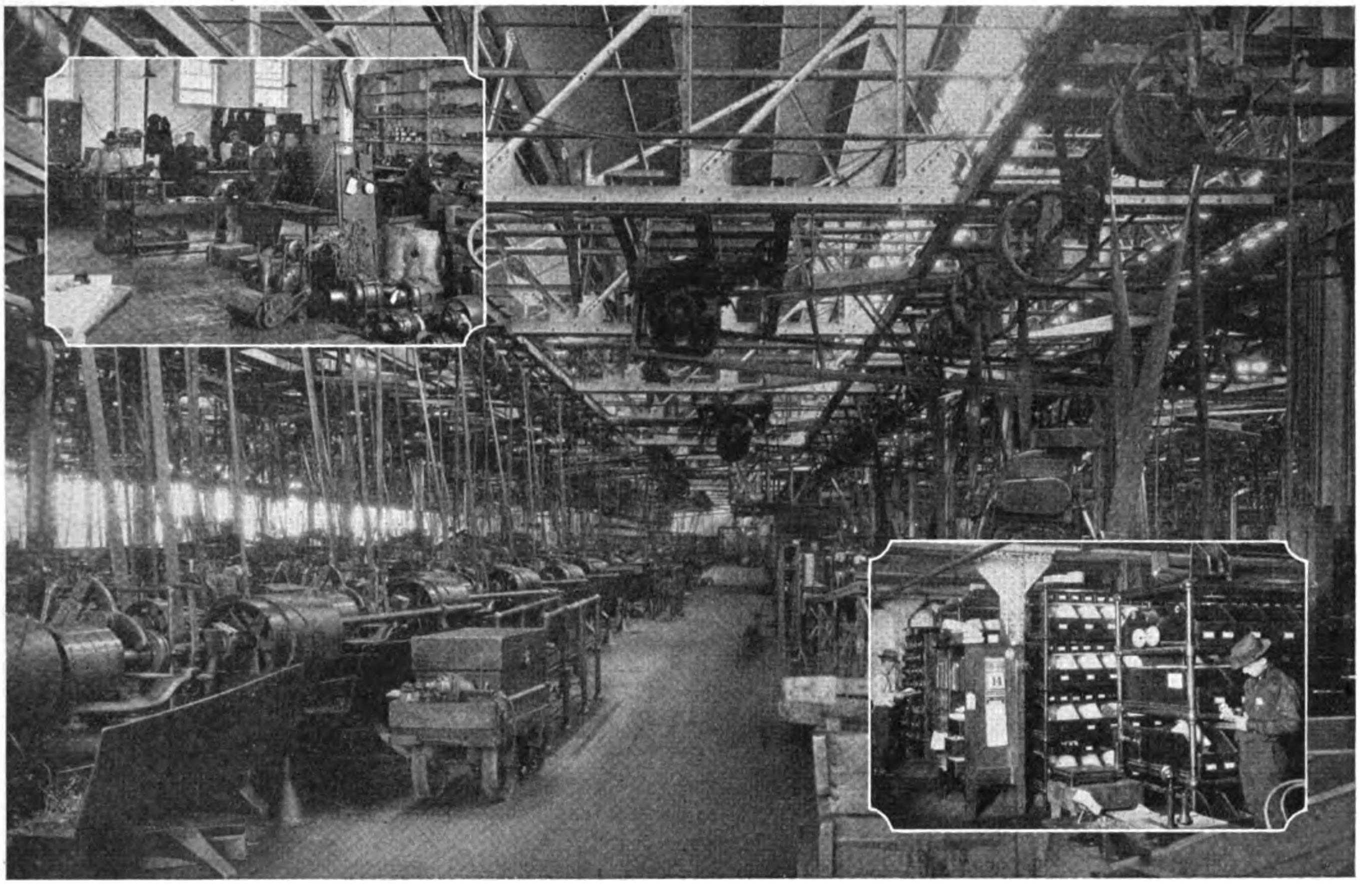
Many individual drives are used, particularly in the stamping plant.

(Please turn to page 81)

Fig. 11—Here is a permanent graphic meter installation for making tests on machine shop motors.

Thirty squirrel-cage motors are controlled from this board. By means of a double bus system, the motors are all started from the same auto-transformer. Also, through the use of this bus system either of the two Esterline-Angus graphic wattmeters mounted on the end panels may be switched on to any motor for running a load check.





This is an analysis of

Maintenance Practice and Organization Methods

as applied in 80 industrial plants to the selection and care of equipment, handling of supplies, and placing of responsibility for execution of work

By G. A. VAN BRUNT

Managing Editor, Industrial Engineer

RAPID growth of industrial works during the past few decades and increasing complexity of the products made have been attended by a corresponding development of the organization and facilities for handling the maintenance work involved in keeping in proper operating condition the various kinds of electrical and mechanical equipment employed.

A great many of the old-time industrial plants, with a comparatively small number of employees and simple, engine-driven machines, have been replaced with a huge property covering many acres of ground, employing thousands of workers, and housed in great, multistory buildings filled with complicated equipment. In the same way, the old-time "handy man" whose job it was to "fix" anything that needed attention, has been replaced with a well-organized force of inspectors, repairmen and the like, whose work is more or less specialized and is conducted largely in accordance with definite schedules. Under present conditions, with plant production carefully scheduled and controlled, and the necessity of performing every operation in the most efficient manner, in order to meet ever-increasing competition, production delays due to failure of equipment are too costly to be tolerated. Hence, the inspection and maintenance of equipment have taken their place among the most important departmental activities of a modern industrial organization.

The organization of the maintenance department, the frequency with which equipment is inspected and overhauled—in brief, the details of the methods and practices followed in properly caring for the electrical and mechanical systems in industrial plants—vary to a considerable extent with the conditions that exist in a given plant. For example, in some industries such as iron and steel, food products, and so on, failure of almost any important piece of equipment may cause serious losses from damage to or spoilage of material in process, in addition to the losses that are incurred from stoppage of production. Again, in other industries the conditions of service may be so severe, due to the presence of abrasive dust, moisture, corrosive fumes, and the like, that equipment soon deteriorates to the point of failure. In all such cases, the best safeguard against equipment failures, with their attendant expense and annoyance, is thorough inspection at such frequent intervals that weaknesses in the equipment or incipient trouble of any character will be discovered before failure occurs. This may mean inspection of all important

pieces of equipment at intervals of a few hours.

In other plants the conditions of service, the consequences of equipment failures, and other factors, may be such that inspections can with reasonable safety be scheduled for much less frequent intervals than are indicated above.

In any plant, a careful study of the service requirements and the conditions under which the equipment operates, supplemented by the experience gained in operating the equipment under these conditions, will show how the work of the maintenance department can be most effectively and economically organized and conducted.

In this article there are presented the results of an analysis of maintenance practices and procedure, including stock-keeping, in 80 industrial plants, as applied to the equipment in the path of power service that extends from the substation or main switchboard through the various elements of electrical and mechanical power drive equipment and down to the spindle of the machine engaged in production. Supplementing this equipment and serving as the connecting link between production machines and departments are the various devices which are commonly termed material handling equipment. This term includes conveyors, cranes, elevators, electromagnets, tractors, and so on, practically all of which is driven or operated by electrical energy.

The plants from which the data shown in the accompanying table were obtained, are located in various sections of the country and, with few exceptions, are nationally known; they may be considered as typical representatives of the most important industries in which production processes are employed. In their scheme of organization and in their operating methods these plants reflect modern practice and sound engineering.

As will be noted from the table these plants range in size, on the basis of kilowatt-hours of energy consumed per year, from one, No. 40, a steel plant, that uses 200,000,000 kw-hr., to one that uses 60,000 kw-hr. (No. 61, a plant making rubber shoes and soles). On the basis of number of motors installed, and total horsepower rating, plant No. 40 heads the list with 3,200 motors installed, of a total rating of 170,000 hp. At the other extreme, plant No. 10, making chemicals and explosives, has 9 motors installed, with a total rating of 55 hp. In this connection it is well to remember that in some plants or industries the manufacturing processes require comparatively small amounts of power. Altogether, in the plants for which these data were given there are installed 23,228 motors with a total rating of more than 457,800 hp. Of the total number of motors installed 6,318, or 27.4 per cent are rated under 5 hp. The electrical energy consumption of the 54 plants that reported this item is in the neighborhood of 727,200,000 kw-hr. a year. There are 41 plants listed that use over 1,000,000 kw-hr. a year; 8 that use between 500,000 and 1,000,000 kw-hr.; and 5 that use less than 500,000 kw-hr. a year. Ten of the plants have more than 10,000 hp. installed in motors, while 56 have between 1,000 and 5,000 hp. installed. Thirty-two plants reporting use alternating current exclusively; 5 use direct current exclusively; and 43 use both alternating and direct current.

As to the method of connecting the motors and driven machines, belts are used in about 48 per cent of the drives (11,159 belt drives on 23,228 motors). Direct connection though solid or flexible couplings is employed in approximately 20 per cent of the drives (4,321 couplings reported). The remaining 32 per cent of drives are through gears, chains or speed reducers.

In the way of material handling equipment, the 80 plants listed have installed a total of 495 cranes of various types, 696 conveyors, 168 electric and 7 gas trucks and tractors, and a variety of other equipment.

Turning for a moment to the lighting system, the plants reporting have a total of 123,058 lamps installed. A few plants did not report the number of lamps installed, as an accurate record was not available. To keep this number of lamps in service a total of 196,906 renewals a year is necessary. On the basis of the average for all plants reporting, lamps are replaced about 1.6 times a year. The size of lamps used varies from 25 watt to 1,000 watt. Of 65 plants reporting a definite average size of lamps used, instead of the range of sizes, 61 specify a 100-watt lamp as their average size; 10 specify 75- and 200-watt lamps, respectively; 7 specify 50- and 60-watt lamps; 5 specify 150-watt; and 3, 300-watt lamps.

The total number of motor failures a year in the plants listed is 1,654; of the motors that fail, 1,029 or about 62 per cent have to be rewound. An analysis of the causes of these failures shows that worn bearings head the list; 15 plants give these as one of the chief causes of failure. In addition, other causes of failure for which the bearings can probably be considered as directly or indirectly responsible are listed as follows: bearing trouble, 3; oil-soaked insulation, 1; oil slinging, 2; oil, 4; oil on winding, 1. This makes a total of 26 instances in which bearings are a factor in causing motor failures.

Overloads come next, being listed 9 times; then in order come grounds, 6; moisture, 5; old age, and acid, 4 each; dirt, single-phasing, 3; insulation breakdown, old insulation, water and steam, iron dust, exposure (presumably to the weather), dust, careless operation, shorts, 2 each. The following causes of motor failure are each mentioned once: failure of overload relay, damaged insulation (cause not given), steel chips, poor ventilation, hard service, lightning, alkali, oil switch trouble, heat, tight belts.

The highest percentage of failures occurred in plant No. 20, a glass plant, wherein there are reported 215 failures out of 458 motors installed. Aside from several plants in which only a comparatively small number of motors are installed, and no failures have occurred for the past year or so, plant No. 77, making refrigerators, has the lowest percentage of failures: 1 failure out of 220 motors.

In the matter of facilities for repairing electrical and mechanical equipment, 54 plants, 67 per cent of the total, reported that they maintain repair shops for this purpose. Twenty-eight of these repair shops wind all or a considerable part of their own coils; two plants reported that they wind coils only in emergencies.

All but one of the plants listed conduct inspections of equipment on a definite schedule, the frequency of inspection varying according to the conditions. One plant reports that all inspections are made at varying intervals, with no set time for making them. Sixty-nine of the 80 plants employ one or more regular inspectors. A total of 193 inspectors are employed in these plants. In 32 plants motors are inspected once a day or oftener; weekly or oftener

in 32 plants, once a month or oftener in 12 plants and at varying intervals in the others. In practically all cases where inspection of motors is made on a definite schedule, motor control and protective devices, and material handling equipment is also inspected regularly, although in many plants the interval between inspections is longer than in the case of motors.

Thirty-three plants out of 72 reporting make a practice of overhauling their equipment at least once a year; 7 plants overhaul equipment twice a year, one plant overhauls equipment three times a year, and two do this four times a year. In plant No. 52 equipment is overhauled every Sunday. Twenty-five plants report that overhauling of equipment is done as needed, or when possible, as during slack periods, rather than on a definite schedule. In a few plants overhauling is carried on continuously, the repair gang going from one machine to the next in order. Three of the plants that overhaul their equipment twice yearly usually do so around the first of the year and in the summer; two plants find spring and fall more convenient for this work. Of the plants that overhaul equipment regularly once a year, five report that this is done during December or January, two do it during February and March, two in the spring, one in June, ten during the summer and two in the fall.

A study of the amounts of a few typical maintenance supplies used and carried in stock, and the stock-keeping practices of the plants reporting on these items, reveals some interesting figures. It will readily be seen from the table that in the case of wire, for example, three plants, Nos. 21, 47, and 73, appear to have on hand approximately a 3-yr. supply of wire; at the other extreme, plant No. 9 has only a 2-wk. supply on hand. Of the 41 plants reporting, 6 have from 2 wk. to 1 mo. supply of wire in stock; 6 have a 2-mo. supply; 16 have a 6-mo. supply; 5 have a year's supply; and 6 have over a year's supply. The total yearly consumption of these plants is 646,155 ft. of all sizes and 56,730 lb. of wire. Altogether, they have in stock 320,373 ft. and 8,200 lb. of wire.

In the case of carbon brushes, there is likewise considerable variation among the different plants in the relation between the yearly consumption of brushes and the amount kept in stock. At one extreme, plants Nos. 47 and 59 have a 5-yr. supply of brushes in stock; none of the plants has less than a 3-mo. supply. Of 35 plants reporting yearly consumption of brushes and brushes in stock in terms that are directly comparable, 4 have in stock a 3-mo. supply; 8 from 3 to 6 mo. supply; 8 from 6 mo. to 1 yr. supply; and 15 more than 1 yr. supply. Together these plants use 23,090 brushes and have 12,487 in stock, a general average of approximately 6 mo. supply.

Amounts of babbitt kept in stock range from 2 wk. supply, in one case, to a 5-yr. supply for one plant whose requirements are not very large. Out of 35 plants reporting yearly consumption and amount of babbitt in stock, 13 have on hand from 1 to 3 mo. supply; 8 have between 3 and 6 mo. supply; 6 have between 6 mo. and 1 yr. supply; and 7 have more than 1 yr. supply. The total consumption of these plants is 54,919 lb., and there are 13,522 lb. in stock, approximately 3 mo. supply.

The same general relations obtain between the yearly consumption of solder and the amounts in stock. One plant, No. 46, reports a consumption of 100 lb. per year, with 500 lb., 5 yr. supply, in stock. Plant No. 58, with a yearly consumption of 300 lb., has 10 lb. in stock, about 1 wk. supply. With 43 plants reporting, 22 have between 1 mo. and 3 mo. supply of solder in stock; 8 have between 3 mo. and 6 mo.; 8 have between 6 mo. and 1 yr.; and 5 have more than 1 yr. supply on hand. The total consumption of the plants reporting is 13,276 lb.; the total amount in stock is 3,388 lb., representing approximately 3 mo. supply.

Out of 44 plants reporting the yearly consumption and amount of tape in stock, 21 have on hand between 1 mo. and 3 mo. requirements; 16 have from 3 mo. to 6 mo. requirements; 3 have sufficient tape to last from 6 mo. to 1 yr.; and 4 have more than 1 yr. supply on hand. In some instances the consumption and amount of tape in stock is reported as number of rolls; the remainder of the plants report their requirements and amount kept in stock, in pounds. Assuming the weight of a roll of tape to be 8 oz. net, the total consumption of the plants reporting is 18,247 lb.; the amount of tape in stock is 3,536 lb., approximately 2½ mo. supply.

On the whole, the supply of lamps carried in stock, as compared with the yearly consumption, is somewhat smaller than in the case of the preceding items. Disregarding those cases in which plants did not report both their consumption and stock of lamps, or reported one or the other of these in terms of dollars spent, 40 plants reported consumption and number of lamps in stock. Of these plants, 11 have in stock 1 mo. or less supply of lamps; 16 have between 1 mo. and 3 mo. supply; 7 have between 3 mo. and 6 mo. supply; and 6 have between 6 mo. and 1 yr. supply. The total yearly consumption of the 40 plants is 142,571 lamps, while there are in stock 25,383 lamps. This represents a little more than 2 mo. supply.

Analysis of the delegation of responsibility for the selection and maintenance of the electrical and associated mechanical systems and equipment, as shown in the last few columns of the table, brings out some interesting facts.

Seventy-six plants reported as follows on the question of the title of the executive who carries the responsibility for maintenance of all electrical equipment: Chief Electrician, 45; Plant Engineer, 5; Electrical Engineer, Electrical Supt., Chief Engineer, 4 each; Engineer, Mechanical Engineer, 3 each; Electrician, Supt. of Maintenance, 2 each; Maintenance Engineer, Plant Electrician, Works Engineer, 1 each; Master Mechanic and Chief Engineer, jointly, 1.

Out of 76 plants the Chief Electrician or other individual who is responsible for the maintenance of electrical equipment reports to the Superintendent in 29 instances. In the remaining 47 plants he reports as follows: to Manager, 9; to Master Mechanic, 7; to General Manager, 6; to Chief Engineer, 5; to President, Vice-President, General Superintendent, Plant Engineer, 4 each; to Works Manager, Equipment Engineer, Electrical Engineer, Engineering Dept., 1 each.

In thirty plants, out of 70 reporting, responsibility for the maintenance of mechanical power drive equipment is borne by the Master Mechanic. In the remaining plants the Millwright bears this responsibility in 6 instances; Chief Engineer and Plant Engineer, 4 each; Maintenance Engineer, Engineer, Mechanical Engineer, 3 each; Chief Electrican, Foreman of Repairs, Supt. of Maintenance, Foreman, Superintendent, General Foreman, 2 each; Ass't Superintendent, Chief

Machinist, Works Engineer, Electrical Engineer, Mechanical Foreman, 1 each.

The individual responsible for maintenance of mechanical power drive equipment reports to the Superintendent in 35 of the 68 plants listed; to the Manager in 16; to Plant Engineer, Chief Engineer, 3 each; to Works Manager, Vice-President, 2 each; to President, Agent, Equipment Engineer, Engineering Dept., Works Engineer, Operating Foreman, Master Mechanic, Factory Superintendent, 1 each.

In 67 plants reporting, responsibility for maintenance of buildings is delegated as follows: Master Mechanic, 17; Superintendent, 12; Plant Engineer, 8; Chief Engineer, 6; Millwright, Construction Engineer, Mechanical Engineer, 3 each; Maintenance Engineer, Engineer, Supt. of Maintenance, 2 each; Property Manager, Steam Engineer, Works Engineer, Yard Manager, Supt. of Property, Engineering Department, Manager, Carpenter Foreman, Chief Carpenter, 1 each.

In 66 plants listed, these men report as follows: to Superintendent, 25; to Manager, 24; to President, 5; to Vice-President, 3; to Works Manager, Chief Engineer, 2 each; to Agent, Works Engineer, Engineering Dept., Equipment Engineer, General Superintendent, 1 each.

Responsibility for selection of size, type and make of electrical equipment used is delegated thus (78 plants reporting): Chief Electrician, 33; Chief Engineer, 7; Electrical Engineer, Plant Engineer, 5 each; Mechanical Engineer, 4; Electrical Superintendent, Engineer, 3 each; Superintendent, Works Engineer, 2 each; Manager, Plant Electrician, Engineering Dept., Supt. of Maintenance, Electrician, Master Mechanic, 1 each. One plant reports that electrical equipment is selected by conference, but did not give the titles of those who are called.

In addition to these, seven other plants report that electrical equipment is selected by the following individuals jointly: Master Mechanic and Superintendent; Superintendent, Chief Electrician and Master Mechanic; Chief Electrician and Engineer; Chief Electrician and Engineering Dept., Master Mechanic and Agent; Master Mechanic and Chief Engineer; Department Superintendents.

Seventy-three plants report that responsibility for selection of mechanical power drive equipment is delegated thus: Master Mechanic, 16; Chief Engineer, 11; Superintendent, 6; Plant Engineer, 5; Mechanical Engineer, 4; Chief Electrician, Engineer, Millwright, 3 each; Manager, Maintenance Engineer, Works Engineer, 2 each; Equipment Engineer, Electrical Engineer, Supt. of Maintenance, 1 each.

As in the case of the electrical equipment, mechanical power drive equipment is, in 14 plants, selected by two or more individuals jointly, as follows: Master Mechanic and Superintendent, 3; Plant Engineer and Master Mechanic, 2; Superintendent, Master Mechanic and Shift Foreman; Millwright and Foreman; Chief Engineer and Engineering Dept.; Conference (titles not given); Department Superintendents; Superintendent, Chief Electrician and Master Mechanic; Agent and Master Mechanic; Engineering Dept.; 1 each.

Selection of material handling equipment does not differ markedly in so far as delegation of responsibility is concerned, from the selection of mechanical power drive equipment. In 69 plants reporting, this responsibility is placed as follows: Superintendent, 12; Master Mechanic, Chief Engineer, Plant Engineer, 8 each; Mechanical Engineer, 4; Engineer, Works Engineer, 3 each; Manager, Chief Electrician, Maintenance Engineer, 2 each; Equipment Engineer, Supt. of Maintenance, Property Manager, 1 each.

As in the case of power drive equipment, responsibility for the selection of material handling equipment is divided in 17 plants. The groups that bear this responsibility and the number of times they were listed are: Master Mechanic and Superintendent, 3; Chief Electrician and Master Mechanic, 2; Chief Engineer and Superintendent; Chief Electrician, Millwright and Superintendent; Chief Electrician, Master Mechanic and Engineering Dept.; Plant Engineer and Master Mechanic; Electrical Superintendent and Chief Engineer; Conference (titles not given); Superintendent, Chief Electrician and Master Mechanic; Engineering Dept.; Chief Electrician and Millwright; Agent and Master Mechanic; Department Superintendents; Several Departments; 1 each.

Method of Making Tight Joints in High-Pressure Water Lines

SOME time ago the Bureau of Standards conducted tests on high-pressure hydraulic pipe lines, to determine the most suitable materials for wiping the pipe joints. These tests indicated that the most dependable material for pressures around 5,000 lb. per sq. in. was finely divided lead, mixed to a pasty mass with the usual litharge pipe dope.

Recently we installed a special, high-pressure fire system, involving a fairly high pressure of water, and due to the location of the installation, even the slightest leakage was not permissible. Brass pipe was used for this line, with the usual fittings, unions, and other connections.

In making up these pipe joints, the wrapped-thread method was tried first. This consists of wrapping a strand of packing cord around the threads, before screwing up the joint. The result was not satisfactory. The second method tried consisted in using lead in the pipe dope; this also failed, possibly because the lead was not ground fine enough, or because the dope did not have time to set. Knowing the usual trouble incident to making up brass pipe connections, it was decided to tin all joints by applying a thin coating of tin on the threads of the pipe and the connection.

One of the first and most important steps in tinning pipe threads is to see that they are as clean as possible. It is also essential to heat the pipe threads (one of the best methods is to hold them in the molten tin), before applying a good flux, and to have the molten metal clean and hot enough.

Wherever a tinned connection was screwed up and showed evidence of leakage, the torch was applied and it was sweated together. This method was not adopted without much lost time and considerable expense. Under similar circumstances, when brass pipe is used, we intend to save the cost of experimenting by using this method altogether.

The writer would like to know if anyone else has found a different method of equal simplicity for making joints in brass pipe absolutely free of leakage, while the pipe line is maintained under constant pressure, at all times.

Washington, D. C. G. A. LUERS.

MASTER MECHANICS of large industrial works have, probably, more miscellaneous and varied duties and responsibilities than any other plant men. The large area which they serve helps to make their problems more complicated, by increasing the difficulty of keeping in close contact with the men working under them. In this article, Mr. Slivinski tells about his work as Master Mechanic of Deering Works, International Harvester Co.

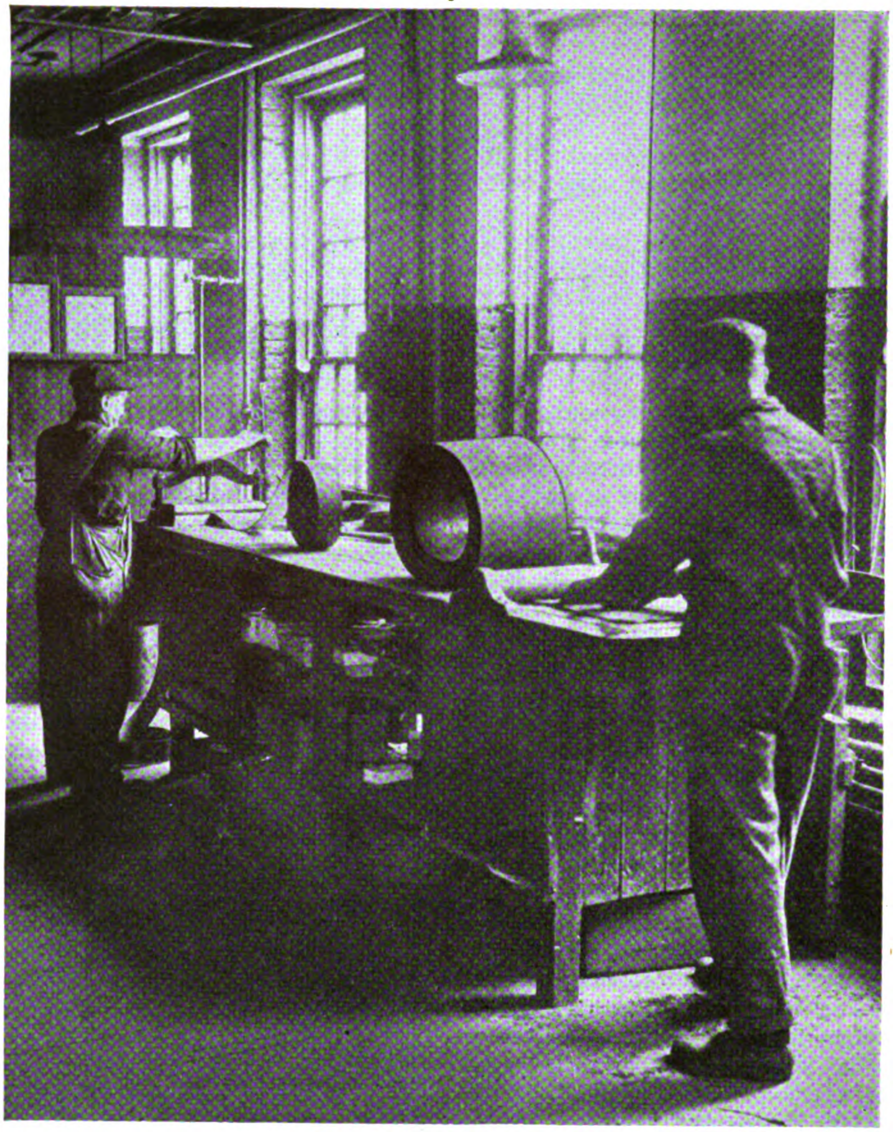
Some of the

Mechanical Maintenance Policies and Practices

which are used to keep an old plant and its power transmission equipment operating at high efficiency with low upkeep

By HUGO R. SLIVINSKI

Master Mechanic, Deering Works, International Harvester Company, Chicago, Ill.



In this section of the repair shop leather belts are cleaned, overhauled, recemented, put in good condition and placed in stock.

IT IS only through careful attention to the little details that maintenance work can be placed on a dependable and substantial basis. It might be possible to take a new, well-constructed, and properly-planned industrial plant and keep it in first-class operating condition at a comparatively low expense and with a correspondingly small amount of trouble. The problems connected with bringing an old plant up to good operating condition and keeping it there are much more numerous and complicated and can be solved only by careful planning over a number of years.

The maintenance cost and much of the trouble which usually goes with it can, by careful forethought, planning and attention to details, be brought down, even in an old plant, to a figure which the man in charge can be proud of. This, of course, requires time as the conditions would seldom permit a complete change or revamping of the entire plant at one time.

In this, it is extremely important to understand what are the causes of the troubles of operation and how they may be eliminated. I have had ample opportunity to try out some of my ideas in the plant with which I have been connected for the past ten years. Portions of this plant are about 40 years old and cover several acres. The principal product is farm machinery. The types of manufacturing include woodworking, a variety of metalworking processes, a foundry, and other special related work.

The principles which I have adopted for planning improvements of conditions and carrying on operations may be of value to other readers of INDUSTRIAL ENGINEER who may be faced with similar problems.

The work of the Master Mechanic of the average industrial plant is probably broader and more inclusive than the activities of any other plant executive. His work usually includes repairs to both machinery and buildings, general maintenance work, construction work, particularly if it is not extensive, erecting of machinery and auxiliary equipment, dismantling, moving and re-erecting machinery, a general supervision over most of the mechanical and sometimes electrical work, and over practically all tradesmen, such as carpenters, millwrights, and so on, except those directly connected with production. In addition, the Master Mechanic is generally expected to be the inventive genius of the plant, and develop new devices, machinery and, frequently, improve methods of performing particular operations or processes.

In that the Master Mechanic in his work travels from one end of the plant to the other and must study the related details of the manufacturing operations, he has an excellent opportunity to investigate

and suggest many methods of reducing the cost of manufacture. This is especially true along the lines of safety and material handling. He usually looks after the design, installation and improvement of safeguards. The fact that he can watch the operation of the various departments without being drawn into the detail and routine of them, gives him a perspective on much of the work which enables him to formulate ideas on material handling and devices and equipment which help to reduce the man-power required.

In addition to these, practically every plant has a multitude of miscellaneous duties, many of which are placed in charge of the Master Mechanic, often because there appears to be no other place to put them. Among these duties are janitor work, and frequently some special duties incidental to his particular plant. This article takes up some of the points affecting his activities, particularly as they apply to maintenance work.

The problems in connection with the maintenance of the power transmission equipment, both mechanical and electrical, are perhaps of most importance in that continuous operation of the plant is entirely dependent upon their functioning.

For most kinds of manufacture, I am in favor of group drives. Also, I am partial to leather belts. Approximately 90 per cent of the machines in the plant with which I am connected are belt-driven. Leather belts are used in practically all cases except on screw machines where they would soon become soaked with oil, and in some departments where the heat is too severe. For these, we use specially-treated, fabric-base belts.

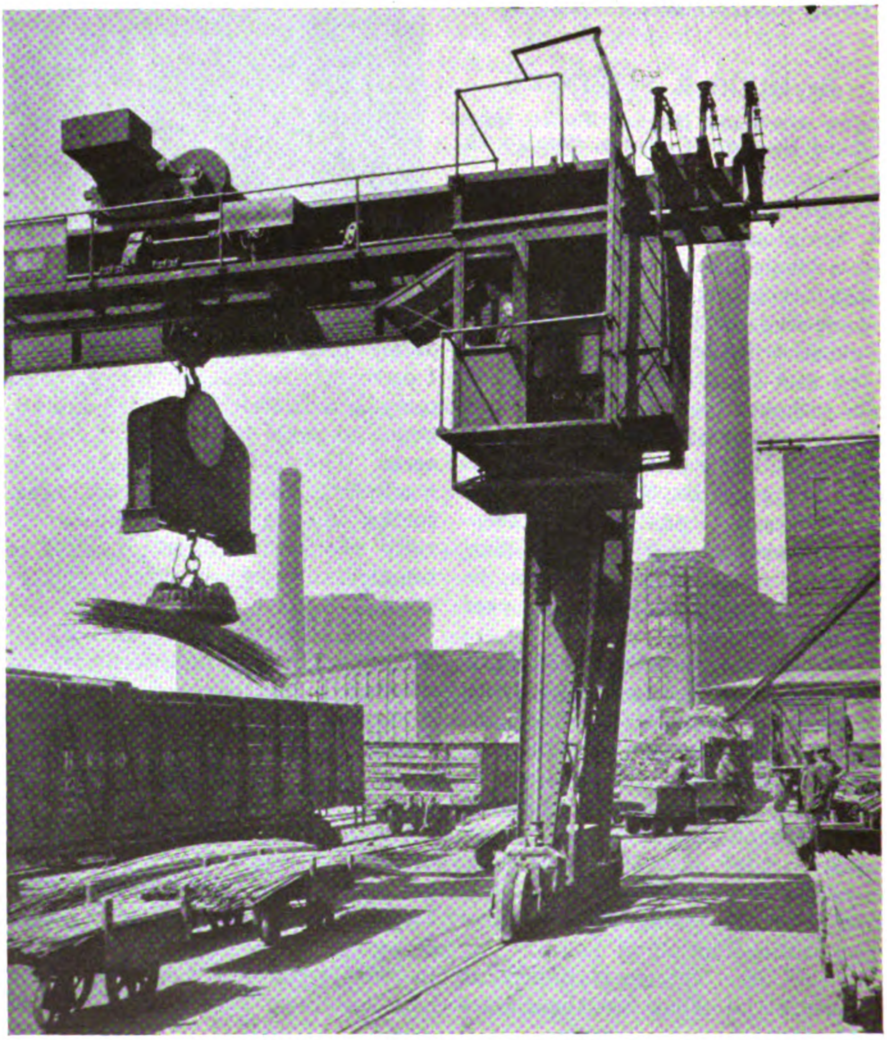
Each department has a combination belt man and oiler who tightens all the belts in the department and oils the lineshafting, but not the motors. On the smaller belts, up to 6 in. wide, a special wire belt lacing with rawhide or Bakelite hinge pins is used. This is not only easy to apply, but is lasting. The belt man takes the lacing machine directly to the job and the idle machine is operating again within a few minutes.

On fabric-base belts I prefer plates and rivets, for the larger sizes, and for belts under 6 in. wide, a special curved plate with projecting teeth which are driven through the belt and the ends clinched, is used. Leather belts over 6 in. wide are cemented endless. The problem of losing belts has been overcome by requiring that an old belt be turned in before a new one is issued. In this way, the belt loss in the plant is negligible.

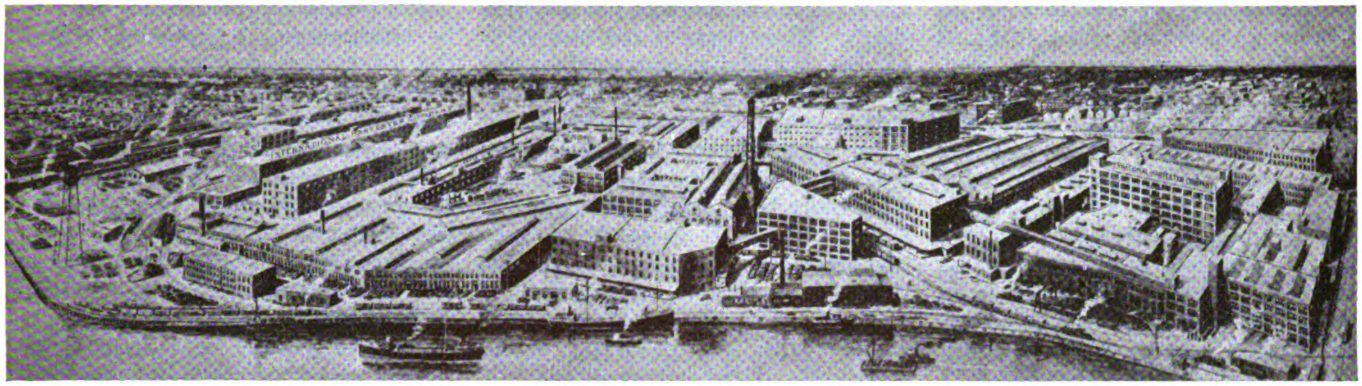
In addition, old belts after they have been removed are cleaned by soaking them in benzine and then scraping and rubbing the grease out of them, loose plies re-cemented, short pieces built into longer belts by cementing together, trimming the edges where necessary, and finally re-oiling the belt so that it is ready to be used again. These rebuilt belts are put in rolls in stock to be issued out as necessary. In addition, we are gradually using up an old 52-in., three-ply belt taken from an engine drive operating the woodworking department. Pieces are cut off this as needed. On belts 6 in. wide and larger, the worn ply is left on. For smaller belts, the worn ply is removed, which leaves a two-ply belt. The leather in this old belt is in very good shape although it had been used for years. The smaller belts which are cut from it will probably have an equal life in the plant. These belts are oiled and dressed if necessary before putting into use. This source of supply is responsible for a very low belt cost. Belt records are not kept although at one time they were used. When the best method of treating and handling belts was found, this record and its expense was eliminated.

The next important part of a power drive installation is the lineshaft. In lineshaft work, it is well to standardize on speed, diameter of shaft, and type of construction to support shafting, bearings, and hangers. All lineshafts operate at 200 r.p.m., except in the woodworking department, where they operate at 250 r.p.m. An exception also is made in the lineshaft driving the tumbling barrels.

Under former conditions lineshaft bearings had been a source of considerable trouble. It was finally decided to standardize on roller bearings and they were tried out on one



This special gantry crane was installed to unload incoming steel. The steel is lifted from the cars by a magnet and the weight taken by the special scale. These trailers are hauled away by tractors. This installation in its first year more than saved its cost by decreasing the number of men required.



The extent of the Deering Works is shown in this view.
This is one of the principal factories of the International Harvester Company, in Chicago. The large area which must be covered is one of the problems which faces the Master Mechanic in his activities. As is often the case, this plant has repeatedly been enlarged with the result that some of the buildings are quite old while others are modern.

shaft. Since that time whenever a lineshaft is taken down for any cause or is overhauled extensively, standard roller bearings have been inserted in place of the former bearings. At present, practically the entire plant operates on roller bearings. This has brought lineshaft troubles down to almost nothing. Occasionally, when it is necessary to add a night force and so put on new oilers we have had a little trouble. This has never been serious, at least compared with the former condition.

It is well to standardize on the size of shafts and in the method of erecting them. It is frequently necessary to move or change a lineshaft. With standard dimensions of units or methods of supporting, this interchange is much more easily made. Compression couplings also make it easier to change a lineshaft. With compression couplings it is possible to use solid pulleys and, if desired, solid instead of split bearings. Also, when the couplings are taken off, the shaft can be stored more easily or handled with less likelihood of springing, than if flanged.

A standardized method of supporting lineshafts has many obvious advantages. Primarily, the men always know how the job is to be done. Practically all of the buildings are of mill construction which makes it much easier to standardize on the method of supporting the shaft than if varying types of construction had been used. This construction consists of longitudinal pairs of angle irons which form rails and are placed close together with sufficient space between each pair for the bolts which attach the feet of the hangers. The pairs of angle irons are in turn supported on cross angles which are fastened with bolts or lagscrews to the ceiling timbers. A long lagscrew extends from this cross angle to the ceiling from midway between the pair of longitudinal rails and provides additional support.

The feet of the hangers are planed, which gives a firm footing and permits them to fit tightly and evenly against the angle-iron rail support. With this construction a hanger can be shifted a few inches or a foot to take care of placing any pulley, or this construction can be taken down and moved to a new location along with the shaft. I also favor drop-end hangers as then the shaft can be put together on the floor and lifted up into position or let down and dismantled as desired.

Tumbling-barrel drives are bothersome problems in connection with most foundry work. In one case we were faced with the problem of installing a number of tumbling barrels in a very compact space which necessitated running the shaft underneath the barrels. The tumbling barrel rests on each end on a pulley on the lineshaft and an accompanying idler pulley. Both pulleys are of the same diameter and the shafts for the two are placed a short distance apart and at the same level. The ends of the barrel rest on and between the two pulleys. The weight of the tumbling barrel holds it down on these pulleys and the rotating lineshaft pulley revolves the barrel. The shaft is revolving all the time at a speed which drives the tumbling barrels at 200 ft. per min. To stop and empty or fill any barrel, a third pair of pulleys is forced against the tumbling barrel which lifts it free from the lineshaft. This drive has given no trouble and has now been in use a number of years. Roller bearings are used here, the same as on other lineshafts.

I have been a firm believer in locating the sources of trouble in the plant and, whenever possible, substituting something else for the equipment which causes the trouble. As an example of this, clutches were located on the lineshaft to connect up a number of machines. As these were not operated regularly and continuously as on a press, we made a change and used a countershaft with a shifting belt and loose pulley. This increased the length of belt and added a countershaft, the cost of which would have been counterbalanced by a new clutch. However, as all maintenance work on a clutch when it is so located must be put in after hours so as not to stop the lineshaft, we felt that a beneficial change had been made.

On machines which must be thrown in and out quickly, as presses, gears, and similar equipment, where a clutch is required because the belt shifter would be too slow, I have found it more advisable to put the clutch directly on the machine. In this way, whenever any maintenance work is necessary on the clutch, the belt can be thrown off the pulley, the adjustment made, and the machine be operating again in a short time.

Another substitution which reduced the operating as well as the maintenance cost considerably was to replace a train of gears with a worm-gear reduction unit. This not only gave a much more compact arrangement but reduced the number of working parts and increased the ease with which it could be oiled and cared for.

While on the subject of trouble-making equipment it may be well to emphasize a point which is too often neglected in the selection of various types of mechanical power drive equipment. Altogether too often such equipment is purchased on entirely too close a rating. Suppose that the ordinary amount of power transmitted by a piece of equipment is 2 hp. If this equipment is operat-

ing only a part of the time, or infrequently, it would probably be of sufficient size to carry the load. However, if it is operated continuously, as would likely be the case with a clutch on a punch or other similar tool, 2 hp. would probably be too low a rating for the job, unless the manufacturer had made a special allowance in his rating. Ordinarily, this is not the case as the rating is usually made on ordinary work. Every piece of power drive equipment, whether it is a clutch, coupling, variable-speed drive, belt, or other device, should be of sufficient rating or rather sufficiently overrated to stand any service which may be placed upon it. This extra allowance alone has much more than paid its increased first cost by decreased maintenance.

It is an expensive policy to keep large stocks of surplus pulleys, shafting and other supplies on hand. Whenever any new construction is planned any materials available are first taken from stock and any more which may be required, are ordered. For the whole plant there are only six spare roller bearings for any replacements which might be necessary in any of the lineshaft hanger bearings in the plant. Perhaps this would not be possible for plants which are not located so close to jobbers and supply houses as are plants in Chicago.

Another device for facilitating millwright work is a special platform which can be moved from place to place and erected under the lineshaft, straddling machinery if necessary, to provide a safe and convenient place for the workmen to stand, with some space for them to move about. If the ceilings in the building are practically all of one height the legs may be made solid and not with extensions. The platform shown in an accompanying illustration serves the purpose quite well. This has a chain railing and a platform made of five pieces including the toe-boards. The toe-boards are fastened on by hinges and may be folded back for ease in transporting. The pipes at the corners which support the chain railing, may be lowered to make the entire unit more compact and enable it to pass through doorways more easily.

Practically all large motors driving the various lineshafts in the production department are provided with an extended shaft with pulleys on each end. In this way, belts are connected from each end of the motor to separate pulleys on the lineshaft. This permits the use of a smaller belt drive and smaller pulleys. For example, on the 75-hp. motors which are used on many of these groups, each belt is driving only about 37½ hp. Also, with two belts there is no tendency to pull the motor askew. It is easier to keep the tension and causes less trouble than if a single belt were used.

We have comparatively little trouble with our electrical equipment. Electrical energy is generated at 550 volts, three-phase, 40 cycles. Induction motors are used on most all of the drives; a few variable-speed motors are supplied with direct current from a separate generator.

One man oils and inspects all of the 900 motors in the plant. In addition, the foreman of each department is supposed to watch for any exceptional heating of the motor and report it. Practically all motors are mounted on the ceiling or where they are out of the way from all damage, except by neglect.

The question of whether a plant should make its own motor repairs is open to discussion. In a large city where there are a number of companies which make a specialty of this work, it is generally advisable to send the motors out for any rewinding or extensive repairing. Bearings should, of course, be changed in the regular repair shop. If a company has a large amount of motor repair work, it may then be advisable to do its own repairing. However, investigations should first be made to determine *why* a large amount of repairing is necessary. Where outside facilities for quick repairs are not available, it would probably be wise to make provision for doing this in the plant. With an average of only about one motor to repair a year (exclusive of bearing troubles), we send this work outside. Miscellaneous electrical repair work is done within the plant.

When a Master Mechanic has the repair and rebuilding of all production machinery, together with the design and building of many new special machines, his machine shop is probably one of the largest divisions of his department. The machine shop under my supervision includes a large variety of machine tools capable of handling almost any type of work. All standard machine tools are purchased for production processes but some machines are designed and built for special work.

Any necessary mechanical repairs to transmission equipment, or for the plant, are taken care of in this department. Similarly, there are special carpenter and paint shops and other departments which devote a large proportion of their time to making equipment or supplies for the production departments and at the same time taking care of necessary maintenance activities. The extent and functions of these departments depend, of course, upon the nature of the work and the other facilities within the plant, as well as upon the policy of the company in this respect.

With machinery, the same as with lineshafting, it is false economy to attempt to use any but the best bearing material. For example, on high-speed, medium-pressure bearings, a copper-base, high-grade babbitt is used. Lower grade babbitts are used on low-pressure, slow-speed bearings. Bronze bushings are usually used on rolls and on punch presses where the bearing pressures are high. Each machine is oiled by the operator.

Whenever a machine is taken down and repaired or overhauled, it is always given a coat of paint. This freshens up the machine and the operator looks on it more as he would a new machine and so gives it better treatment.

While many Master Mechanics want to do all of any extensive construction work incidental to the installation of new equipment and sometimes additions to buildings, I much prefer to have as much of this as possible done by outside concerns on contract. They have better facilities for doing this kind of work and generally the industrial plant man has enough to do with his own work and the necessary inspection and supervision over a firm doing the work on contract, without taking on the heavy duties which would naturally be a part of his trying to do the work himself. On small jobs it is, of course, generally easier and cheaper to do them yourself than to bring in someone from the outside.

Repairs to the buildings, floors and yards, are, of course, a part of the Master Mechanic's activities. A wood floor laid on stringers has many advantages and is my preference, except in foundries, around furnaces and ovens, presses, and similar locations, where it would be impracticable. While it is easier to truck where the flooring is laid diagonally, such floors are very dif-

ficult to repair. Floors laid straight with aisles are easier to repair.

As already stated, safeguards are commonly designed and installed by the Master Mechanic's department. This calls for close co-operation with the Safety Department so as to find out where safeguards are needed and what types of accidents need to be guarded against. A safeguard to be effective should be substantial, neat in appearance and easily removed or replaced, if necessary, to permit adjustment of the machinery. The safeguards, on the other hand, should not interfere with production or operation but still effectively guard the machine or tool so that it is almost impossible for a man to injure himself.

Sometimes these guards are simple and at other times more complicated. For example, in one case a guard was installed which requires the simultaneous action of one foot of the operator as well as both hands of the operator and of his helper. In another case, on a straightening hammer, a sweep was designed to operate by a projecting arm fastened to the die head and sliding in a spiral groove which passes the sweep across the face of the die block in such a manner as to knock a hand out of the way ahead of the hammer. Similarly, guards which protect the hands of truckers have eliminated many of those minor accidents which frequently become infected.

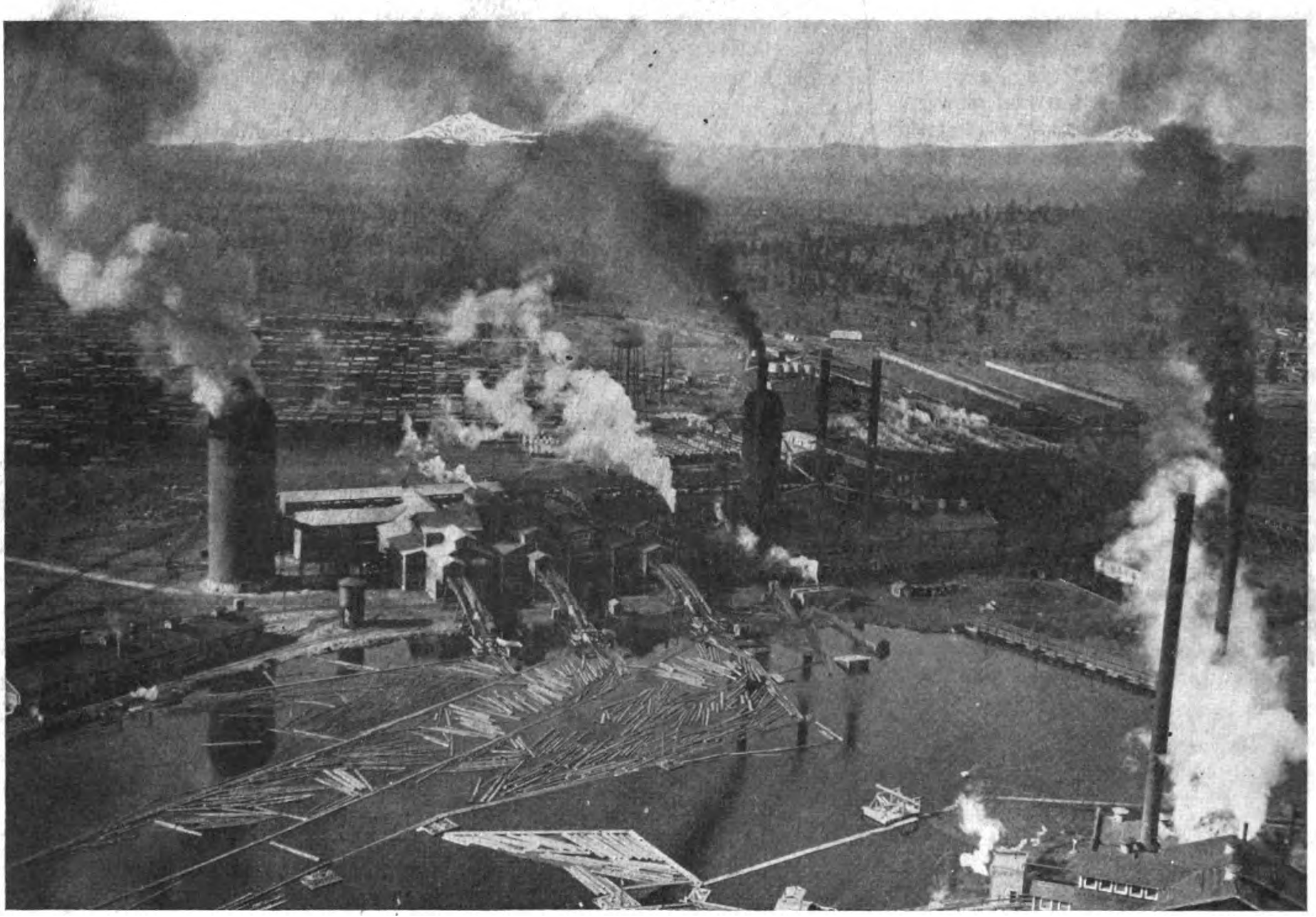
In some cases, it is possible to simplify the operation of a machine and at the same time as it is being guarded. For example, in one case on a large shear the foot treadle which threw in the clutch was difficult for the man to operate in that he had to put his entire weight on it to trip the clutch. An air cylinder was connected in to trip the clutch, with the valve operated by the foot treadle. Extra guards were placed so that the treadle could not be tripped accidentally, and, could be operated from only one position in front of the shear. This made it much easier to operate the clutch, eliminated fatigue, and so increased production.

Material handling offers many opportunities for the man with some inventive genius, and not so closely involved in the work as to narrow his viewpoint, to suggest or design numerous improvements. One instance is connected with the installation of a gantry crane mounted to run on tracks on the outside of two lines of switch track, as shown in the accompanying illustration. This is used either with a magnet or with a hook and sling to unload all steel as received and to load scrap and steel shavings on the car for shipment. The first year this crane was put in, it saved the labor of 36 men daily for a year and more than paid for itself.

The idea for this was worked out roughly and turned in, together with the estimated cost and possible saving, as a suggestion, before the management made any real suggestions for research along that line. If there is any way in which a Master Mechanic or any other industrial executive, can add to the importance of his position, it is by anticipating needs and requirements before anyone else and offering a solution for them. It may frequently happen that his suggestion is not appreciated at the time, but if he is a careful student of his problem and has faith in his idea, all he has to do is to wait and when the right situation arises he will be ready to bring out his idea again and stand a very good show of its being accepted.

In addition to the larger things which require submission to the management before they are carried through, there are any number of little things which come in as a part of the work and can be put into effect at any time.

A special millwrights' scaffold or platform is used on overhead work. The upper illustration shows how the scaffold appears when it is erected. The lower illustration shows how it is knocked down and packed on a truck to be taken from one department to another. Standardized equipment, such as this, facilitates maintenance work; this scaffold can be adapted for practically any job and is easily erected and transported. The platform is made of five boards, with the toe-board hinged on the edge of the outside board. The safety chain and toe-board are easily installed safety features.



In this sawmill of the Shevlin-Hixon Company, Bend, Ore., there are installed more than 200 a.c. and d.c. motors, representing a connected load of 3,000 kw. On page 68 W. B. Cone describes the maintenance organization and methods used in taking care of these motors and the other equipment.

How some industrial plants are

Reducing Operating and Maintenance Costs

by efficient organization of inspection and maintenance work, standardization of equipment, and use of modern testing and repair devices

THE primary function of the maintenance engineer is to keep the plant running. To keep an industrial plant in efficient operating condition at all times requires a well-organized group of men who are trained along definite lines, together with a system of periodic and thorough inspection, backed up by facilities to make any immediate repairs that may be required. With such a background as this, the man in charge of operation and maintenance soon sees ways of reducing operating costs by rearrangement or use of improved equipment, by better methods or better equipment for making repairs, and by careful testing to determine the exact status of the equipment under his jurisdiction.

In the belief that some details regarding the equipment and methods used in handling maintenance and repair work in various industrial plants would be interesting and instructive, the questionnaire shown in the accompanying box was sent to some of the readers of INDUSTRIAL ENGINEER who are in charge of such work.

A study of the letters received in response to this questionnaire discloses that there are various types of organizations for handling maintenance, depending not only upon the size of the plant, but upon the type of industry served.

Contributors to this discussion have pointed out various means that they are using to reduce the cost of maintenance and operation; the more important of these are regular and periodic inspection backed up by a system of records showing what was inspected and when; standardization of repair parts for cranes, motors, control and other equipment; regular checking of air gaps on all motors; standardizing on equipment that is best adapted to a particular application; scrapping obsolete apparatus and replacing it with equipment of modern design; making permanent repairs instead of temporary ones; careful refilling of all renewable fuses by one man, together with more attention to the contact surfaces of blades and jaws of fuse clips; filtering of oil to remove foreign matter injurious to bearings; replacing cast-iron pinions with steel pinions; and many others.

Trouble of a mechanical as well as electrical nature is encountered with equipment. This is, in the main, due to severe operating conditions, such as overloading, improper starting, acid fumes, carbon, dirt, and water as well as poor installation, and lack of proper maintenance.

Use of improved equipment has resulted in a marked saving in a large number of cases. Among those mentioned are the use of sealed sleeve, and ball and roller bearings for motors and other drives; wider use of automatic control, thereby reducing the number of operators required and also reducing the starting duty on motors; use of overload relays, in particular, the thermal overload relay; use of speed reducers in dirty locations, thereby greatly reducing the maintenance required by the equipment replaced; use of flexible couplings and direct connection in preference to other forms of drive; changing from belts to silent chain drives in some instances; use of synchronous motors for power factor improvement; and so on.

The discussions disclose a wide use of portable indicating voltmeters, ammeters and wattmeters for checking and testing the condition of various types of electrical equipment. Particular attention is called to the value of graphic wattmeters and tachometers, as well as devices for measuring insulation resistance.

In the repair shop, too, many improvements have been made that are resulting in economies. Among those items of equipment that are mentioned as being of particular value are, baking ovens; an improved type of gasoline spray for cleaning; paint or varnish spray guns; portable air compressor for blowing out and cleaning equipment, oxy-acetylene cutting and welding equipment; arc welding outfits; and many others.

The letters giving the details of the economies and methods mentioned are quoted below:

* * * *

J. S. Murray, Chief Electrician, Follansbee Bros. Co., Toronto, O. *Question 1.*—Our plant is devoted to the manufacture of high-grade automobile sheets, from the raw material to the finished product. All our equipment is completely electrified. We generate all of our power, having a consumption of about one and one-half million kilowatt-hours per month. We have about 600 motors totaling around 15,000 hp., and station capacity of 7,500 kw. Our Electric Department employs 94 men, and is divided into the following divisions: Inspection, Repair Shop, Construction, Sub-Station, Meters, Crane Operators and Coal Mine department.

For taking care of inspection, plant equipment is divided into three sections with an inspector and two helpers in each of two sections on 8-hr. shifts, seven days a week. The remaining section has one inspector on a 10-hr. day turn, seven days a week.

At the end of each turn each inspector makes out a report, shown in an accompanying illustration, which is sent to my office. The inspectors are responsible for the condition of all electrical equipment in their section, on motors up to and including the motor pinion, as well as all electrical and mechanical work on traveling cranes. Each inspector has a third portion of the equipment in each of the first two sections which he is responsible for from a maintenance standpoint, but he is always available in the entire section in case of a breakdown. These same inspectors also make the cranemen responsible for cleaning and lubricating certain parts of the cranes.

> **Questions Asked Readers of Industrial Engineer**
>
> **(1) Tell us about your organization and methods of handling maintenance and repair work.**
>
> **(2) How and where have you made the largest savings in operating, maintenance and repair costs?**
>
> **(3) What piece of equipment, either electrical or mechanical, gives you the most trouble? In what way? Why?**
>
> **(4) What changes or additions have been made in the past two years to electrical or mechanical power drive or material handling equipment that have improved operating conditions, or cut maintenance and operating costs?**
>
> **(5) What kinds of testing equipment do you use and what have you found most valuable in the inspection of plant equipment?**
>
> **(6) What equipment do you use in your repair shop? What piece or pieces of equipment have enabled you to make the largest savings in cost of repairing electrical and mechanical equipment?**

The Inspection Division is not expected to do repair work, except of a minor character, on spare parts. Spare parts for both mechanical and electrical equipment are located at central points. The inspector's report form shown on page 69 tells what has been used each day and provisions are made immediately to replace the part.

Our electric repair shop is located in a central portion of the plant and is equipped to handle all electrical and mechanical maintenance in the Electrical Department. We have a shop foreman, armature winder, machinist and repair electrician employed here; also we have floor space for two electrical millwrights who work there at times in carrying on millwright work in the department in connection with bearing re-babbitting, machining fits, and similar mechanical operations.

The millwright, inspection and repair shop forces are very closely in touch with each other at all times with respect to the condition and location of required spare parts.

We maintain a Construction Division for the purpose of installing all new work and making changes or improvements when desirable.

We have operators in a central substation, shown in the illustration on page 71, which contains our blooming mill drive, our step-down transformer equipment, motor-generator sets and air compressor drives. All power house feeders enter this building except two feeders to our hot mill roll drives. Therefore, all low-voltage feeders, both a.c. and d.c., leave this substation and are under the care of these operators.

We employ a meter man to maintain our meters properly and make the proper distribution of power charges each month. This man also maintains a close check on pyrometer equipment at the annealing furnaces and checks overload relay settings on the important units. He also takes care of any drafting that may be required, and keeps a check on the insulation resistance of the more important units.

We have about 56 cranemen who are hired and trained by the Electrical Department. All cranemen are subject to the orders of the Electrical Department with respect to the proper handling of crane equipment. This system is very successful.

Complete data on all electrical and mechanical equipment are filed in the Chief Electrician's office, and cross-indexed by a clerk. This clerk also balances daily his disbursements against his storeroom inventory, on both electrical and mechanical spare parts, so that the possibility of overlooking parts used is very remote. We maintain our own storeroom, for important parts, adjacent to the electric shop, and stock detail parts in the regular mill storeroom.

We have our own coal mine with a mine electrician in charge. A motor-generator set is located in the center of the coal field, with a bore hole for direct-current cables leading to the mine for mining machines and locomotives. The maintenance of all equipment in the mine is done at the mill repair shop.

Question 2.—We believe that standardization has saved us more than any other one thing. We have found it possible to limit the sizes of track wheels for the various bridge and trolley wheels on 26 traveling cranes. No effort was made originally to standardize rail sizes or wheel diameters; it was accomplished by consideration of various axle diameters and hub lengths. Very close checks are maintained on motor and control parts, so as to keep down the variety of parts required. We have also made considerable saving through the standardization of gears, brake wheels, shoes, bushings, etc.

Question 3.—We have had trouble with some of our flexible couplings, due to severe service in some cases and lack of proper attention in others. We have corrected this by installing improved types of couplings in some instances and devoting more attention to inspec-

tion and maintenance of the couplings in others. We have also had considerable trouble with mechanical parts on forging manipulator cranes which are used in forging ingots under a steam press. These troubles are being overcome by changes of design and using better material in parts showing the greatest abuse.

Question 4.—The most outstanding saving made in the past two years has been brought about by the adoption of sealed-sleeve type bearings on our general-purpose motors. This type of bearing has reduced our rewinding cost by 40 per cent. Several other changes have helped to lower costs, such as a more liberal use of automatic control at our coal mine, substation, and on hot and cold roll drives.

Question 5.—For testing we use a graphic wattmeter; Weston indicating voltmeter and ammeter; Weston shunts, 25- to 800-amp. capacity; Esterline shunts in 25 to 400 amp. sizes; Westinghouse a.c. voltmeter and ammeter; Esterline "Utility" current transformers, 25- to 800-amp. capacity; Weston millivoltmeter, 0 to 300 volts; Brown Heatmeter, 0 to 2,000 deg.; Biddle Bridge Megger; Jagabi speed indicator; stop watch; potential transformers, 20/1 and 2/1; potentiometer, 75 to 2,000 deg.; Westinghouse portable standard watt-hour meter. We find the graphic wattmeter, Biddle Megger, and the Heatmeter are of much value in performing the work outlined by the meter division.

Question 6.—In our electric repair shop we use a 30-in. American lathe, shaper, drill press, large wheel press, armature banding machine, varnish dipping vats and baking oven. We believe that from a mechanical standpoint the shaper, lathe and wheel press make the greatest savings. From the electrical standpoint, the baking equipment permits greater savings on winding costs. However, we consider all of the equipment indispensable to us because of the large amount of mechanical equipment which we maintain.

* * * *

W. B. Cone, Chief Electrician, Shevlin-Hixon Co., Bend, Ore. *Question 1.*—The Shevlin-Hixon Co., a manufacturer of white pine lumber and lumber products, is located in one of the largest white pine belts in the country. The scope of operations not only includes regular saw mill operation and manufacture of some finished products, such as boxes, etc., in the plant illustrated on page 66, but also logging and transportation of the logs to the mill.

In the saw mill at Bend, Ore., there are over 200 motors requiring both alternating and direct current and drawing an average load of 3,000 kw. from our own power plant. Besides operating and maintaining the power house and motor drives throughout the plant, the Electrical Department takes care of a fleet of storage battery industrial tractors.

Our electrical maintenance crew consists of five men, which is an unusually small number for a plant of this size. Each man has a great deal to do, but due to the definite assignment of responsibility, we are getting very good results. When much construction work is to be done, more men are added.

Question 2.—If there is any place that the "ounce of prevention" proverb applies it is in the maintenance of electrical equipment. All control equipment is gone over once a month and carefully inspected for signs of overload or trouble. Motors are given a similar overhauling and all worn parts are renewed or repaired. In addition to this thorough overhauling, daily inspection is given the equipment by the maintenance men assigned to the various departments, and who are held responsible for the equipment.

Questions 3 and 4.—Fan motors are very important machines to keep running in a lumber mill, and inasmuch as they are mounted overhead so as to make room for the sawdust pipes, they are difficult to inspect. Besides the usual forms of motor protection, we are now using a thermal overload relay which is mounted directly on the stator laminations of these fan motors. These relays are arranged to open the circuit on the low-voltage release of the compensator and stop the motor, whenever its temperature reaches 65 deg. C. These thermal relays keep close watch of the motor temperature and danger of single-phasing, with resultant burnouts, has been eliminated.

Question 5.—Our testing equipment consists of indicating voltmeters and ammeters for both alternating- and direct-current service, wattmeter, magneto, and an insulation resistance measuring set with a range of 100 megohms. This latter instrument is indispensable for testing purposes. We also have a millivoltmeter for testing d.c. armatures.

Question 6.—We do all our repair work in our own shop. In this shop we rewind our motors and dip and bake the smaller ones in a small baking oven. The larger motors are dipped and baked in one of the kilns used for drying lumber. We make our own coils for motors below 10 hp. rating, but carry a complete stock of coils for the larger motors. In this same shop, brass and bronze bearings are bored and machined to size and steel-clad bearings are rebabbitted. Adjoining the repair shop is a storeroom with complete line of spare parts and supplies for the Electrical Department. This material is specified and ordered through the Purchasing Department by the Chief Electrician.

* * * *

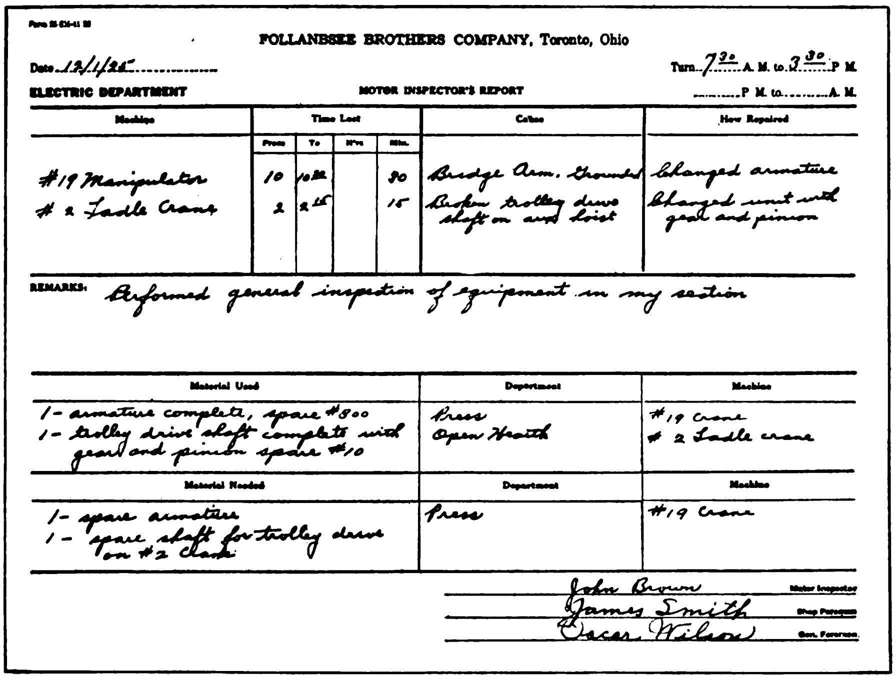
Lee F. Dann, Chief Electrician, Donnacona Paper Co., Donnacona, Que., Can. *Question 1.*—In our plant we have approximately 175 motors ranging in sizes from 1 to 1,500 hp. There are five 1,500-hp. synchronous motors and two 1,200-hp., wound-rotor, induction motors. These machines are inspected weekly, blown out with compressed air and thoroughly wiped off. The air gaps on the motors are checked once a month and if any variations are shown immediate adjustments are made. In addition the insulation is given a Megger test once a month.

The remainder of the motors are well distributed in every section and corner of the plant and yard on all kinds of drives, and subjected to all kinds of acid fumes, temperatures, dust, and moisture.

One man makes two daily inspections of all these motors, looking after the oiling, cleaning and any other points that require attention. From 75 to 90 per cent of all paper mill motors operate continuously 24 hr. a day, six days per week; therefore the motor inspector must not only watch the motor, starter and other electrical equipment in each particular case, but must also keep a lookout for mechanical troubles. Paper manufacture is a sequence of operations, one dependent on the other; therefore each motor must be ready at all times to do a full day's or a full week's work. Even a small motor burning out a bearing might cause an expensive shutdown and it pays to have a motor inspector who keeps a conscientious watch on everything.

In the electrical repair shop three men are employed, one on each shift of eight hours. These men handle all calls throughout the mill at any time and make the necessary repairs or adjustments to keep the apparatus running, unless a new bearing or a change of motors is required. In the latter cases they are assisted by both machinists and millwrights. In addition, these three men repair all machines brought into the electrical shop for extensive repairs. Practically all rewinding is done in the shop. This is necessary here as the nearest repair shop able to handle this kind of work is 150 miles away. Owing to the length of time required to obtain repair parts, a fairly large supply is kept constantly on hand, including coils, magnet wire, motor bearings, starter parts, relay parts and switch parts. These supplies are not in the regular storeroom, but are in the electrical shop where they can be had at a moment's notice. The repairmen are required to keep a close watch on supplies and immediately tell the man in charge of any needed material. Five other men are employed on new construction, changes and line work. The mill has considerable line work, as all feeder circuits are run on the roofs of the building open construction.

We have a system of weekly inspection, done every Sunday while the mill is closed down. Lists of apparatus have been made up and divided into what comprises a full day's work for the repairman and a helper drawn from the construction gang. It requires six weeks to cover the plant completely; thus each piece of apparatus is inspected at least eight times a year. A few pieces of equipment that see severe service and are very important are inspected weekly by the repairman in addition to his regular Sunday work. Lighting equipment is cleaned regularly by one of the younger helpers in the construction gang. A great many of the lamps are in hot places rather difficult of access and we find it more economical to have the work done when the mill is closed down on account of the tendency of the men to slight the work if done when the mill is running.



FOLLANBSEE BROTHERS COMPANY, Toronto, Ohio

Date 12/1/25 Turn 7^30 A. M. to 3^30 P. M.

ELECTRIC DEPARTMENT MOTOR INSPECTOR'S REPORT ......P. M. to ......A. M.

Machine	Time Lost From	To	Hrs.	Min.	Cause	How Repaired
#19 Manipulator	10	10^20		20	Bridge Arm. Grounded	Changed armature
# 2 Ladle Crane	2	2^15		15	Broken trolley drive shaft on aux hoist	Changed unit with gear and pinion

REMARKS: Performed general inspection of equipment in my section

Material Used	Department	Machine
1- armature complete, spare #800	Press	#19 Crane
1- trolley drive shaft complete with gear and pinion spare #10	Open Hearth	# 2 Ladle crane

Material Needed	Department	Machine
1- spare armature 1- spare shaft for trolley drive on #2 Crane	Press	#19 Crane

John Brown Motor Inspector
James Smith Shop Foreman
Oscar Wilson Gen. Foreman.

A motor inspector's report, that is more than a list of equipment, which was supposedly inspected. This form is used at the Toronto plant of Follansbee Bros. Co.

Question 2.—A large saving in repair parts is due to our regular inspection system. Take, for example, 100 starting compensators; these require numerous contacts and small parts which are not very expensive so far as first cost is concerned, but can be made very expensive unless properly and completely used. All contacts removed from starters are sorted over in the shop; those that can be filed or ground so as to be used again are laid aside and put into working order by the repairmen in spare time. These second-hand parts are used only on the starting position of compensators, new contacts being used on the running side.

Question 3.—Motors, starters and associated mechanical equipment used in yard service cause the most trouble. These installations are more or less temporary, and as usual with jobs of this kind almost anything goes. Motors are never set level, thus causing bearings to heat through loss of oil and end thrust. The natural results of this are stators and rotors rubbing, causing windings to be damaged, and oftentimes burned out. The starters and relays are severely used, being moved from one location to another and often abused by the operators.

The next in order for serious trouble are a few motors under severe operating conditions such as pump and fan motors in the sulphite mill which are exposed to strong acid fumes. The windings of these machines are short-lived at the best, and in order to keep the insulation in operating condition the motors are brought into the shop two or three times a year and given a thorough drying and cleaning; afterwards a coat of acid-resisting, insulating varnish is applied with a spray gun. Varnish is applied at various pressures depending on the condition of the insulation. If the tape on the coils appears to be loose or rotten, only 15 or 25 lb. pressure is used; if tape appears to be in good condition more pressure is used.

Question 4.—The growing tendency to use ball or roller bearings and the trend towards the use of more direct-connected apparatus are important. Machines and motors are connected indirectly by the use of speed reducers, of which there are numerous kinds on the market. Connecting directly is accomplished by flexible couplings or magnetic clutches. Two years ago an extensive addition was completed at this mill and all pumps and fans that could be direct-connected without too expensive a layout, were thus connected. These direct-connected machines have caused very little trouble and the operating expenses have been small as compared to some of the older belt- or gear-driven apparatus. The cost of driving power is much less, as the friction load was reduced by eliminating belts and countershafting. The mill load totals over 15,000 hp. of electrically-driven machinery and a reduction of 1 or 2 per cent of the friction load means a substantial saving in the power bill.

Question 5.—In making routine tests of motors for power consumption or load, we use a Weston polyphase wattmeter, with variable-ratio current transformers. The potential coils of this meter are wound for 600 volts and as our motors are all 550 volts, with the exception of a few large ones, it is not necessary to use voltage transformers. We usually connect a pair of ammeters in series with the wattmeter current coils and then by using a voltmeter the power factor is easily determined and we always have proof of the correctness of our meter readings. For special tests where load and variations are required over a long period of time a General Electric graphic meter is used. For insulation tests a Megger is used and all the large machines are given periodic tests. In case of doubt on any of the small motors, the Megger is again brought into service. We find this to be a very useful instrument in the repair shop on both new and repaired windings or other equipment requiring a high-potential test. The Megger determines the condition of the insulation and if it is in good shape the apparatus is given a high-potential test.

Question 6.—Our repair shop is not very well equipped as plans are under way to build a larger, better shop in the near future and then to purchase the necessary shop equipment. We have a few pieces of shop equipment which, while made in the shop, serve the purpose very well. For winding coils of the many different sizes and shapes required we use an adjustable form on which both coils for open and semi-closed slots are made. In winding the coils for open slot machines the conventional loop is wound and after taping the coils are pulled to shape by hand. Coils are dipped in varnish and baked over a steam-heated coil before placing in the motor. Several methods of applying the varnish and several kinds of varnish were used on closed slot coils before we found one that suited all conditions.

We had a great many old motors with soldered rotors and as these were a constant source of trouble a remedy was needed. Several of these rotors were welded and the results were so gratifying that the practice was continued. Today we have very few rotors which give trouble. As soon as one shows signs of trouble the motor is replaced and the troublesome rotor is welded. Many seem to think that welding does not pay, due to starting difficulties. Rotor welding should be done only by a welder who knows this work. Any good welder can make a tight job, but a good many put on so much metal that the resistance of the rotor is lowered unduly. We have had not less than twenty rotors welded and in no case have we had starting difficulties.

In the shop we use a portable spray-gun outfit manufactured by the DeVilbiss Company, Toledo, Ohio. Motors showing signs of oily insulation are dried out and sprayed with Sterling varnish or Ohmaline No. 68, an English varnish that is pliable.

* * * *

J. Elmer Housley, Electrical Engineer, Aluminum Company of America, Alcoa, Tenn.—The time-tried watchword of the plant engineer is preventive maintenance. Nearly every machine gives evidence of distress before failure, either by sound, smoke, vibration or during regular testing by proper meters. Where operation is forced and a suitable occasion is not presented for inspection and repair before failure occurs, one failure may be excused. Why should there be a second failure? Usually because the underlying cause is not discovered. If there is a shaft out of true, a pump out of balance or any other condition existing that is *the* cause, there can be no elimination of the effect, such as burned bearings, until the cause is discovered and removed.

Maintenance should be given more consideration by the designing as well as the operating engineers. Should troubles develop that were not foreseen, the necessary cost of revision is nearly always repaid in a short time by savings in maintenance and in delays.

One noteworthy advance in maintenance methods is the increasing use of the electric arc welder, with excellent results in general plant repairs; the use of the welder frequently invades the fabrication of sheet metal parts after it is once in the plant.

Repair costs are being lowered by mechanical transmission devices for reducing the speed between motor and machine. A good flexible coupling is a very necessary adjunct to take care of shocks during the starting of the motor. In the short period that the new type synchronous motors, with clutch devices for giving high starting torque, have been in service they have made a good impression and offer an effective method of reducing distribution and wiring costs and improving voltage regulation.

* * * *

William J. Mildon, Superintendent of Power and Equipment, Madeira-Hill Coal Mining Co., Philipsburg, Pa. *Question 1.*—Maintenance and repair work are under the supervision of the Chief Electrician or Master Mechanic at each mine, or mines, where there are more than one in the vicinity. Their assistants are promoted from men having experience in the operation of the equipment. The number of men required is determined by the size of plant and ranges from three to twenty.

Question 2.—Savings in maintenance and repair costs have been made by standardizing on equipment best suited to the various requirements, scrapping obsolete apparatus, making periodical inspections and permanent repairs instead of temporary ones. Also, the installation of a 300-hp. cylindrical conical drum hoist, having all wiring in conduit, soundproof apartment for primary and secondary contactors and a resistor rack to facilitate inspection and removal for repairs has saved us money.

Question 3.—The equipment causing us most trouble is the gathering pumps. The trouble is of a mechanical nature, due chiefly to the severe operating conditions, caused by continuous service and infrequent loads through pumping a mixture of air and gritty water, thus cutting packings and cylinder liners.

Question 4.—A marked saving in operating cost was made by the installation of an automatic auto-starter on a 25-hp., 2,200-volt fan motor, which is located two miles from the main plant. A saving was also made by the application of a silent chain drive to replace spiral gears which caused too much end thrust on motor bearings, resulting in vibration of the rotor. The application of 99 per cent nickel to replace acid-resisting bronze on heavy-duty, high-speed, centrifugal pump rotor parts, such as shafts, impellors, labyrinth rings and wearing sleeves, has netted a saving in maintenance amounting to over 400 per cent in two years; the last inspection showed no signs of wear.

Question 5.—Testing equipment that we have found of much value in inspection and maintenance as well as for power and load tests are, a fault-finder or 50,000-ohm magneto for locating trouble; portable, d.c. voltmeters, millivoltmeters, and ammeters; portable a.c. voltmeter and potential transformers, ratio 20-1; portable 0/5, 0/10 amp. ammeters; and 5/25, 50/100-amp. current transformers.

For installation tests the Esterline Utility Graphic wattmeter is used in conjunction with the above indicating instruments and is the most valuable of instruments for the reason that periodical tests may be compared.

For testing insulation we use the voltage drop test in conjunction with an adjustable resistor, or load box and ammeter. We use a recording voltmeter for testing line voltage, with multipliers for a.c. or d.c. If a test is to be made only for power consumption, we use watt-hour meters.

Oils from transformers, oil switches and circuit breakers are tested periodically with a General Electric portable oil testing cup and transformer. The oil under test must not break down below 17.5 kilovolts, when using 1-in. discs separated 0.1 in. in the testing cup, to be considered in fair condition. Below that standard, the oil is filtered.

Question 6.—The equipment in our repair shops consists of thread-cutting engine lathes with taper attachment, drill presses and radial drills, shapers, milling machines, emery grinders, portable electric drills and hammers, portable keyseating machines for field work, portable electric grinders for truing up large collector rings and commutators in their bearings, electric mica-cutting saws for slotting commutators, and electric welders having a range of 15 to 250 amp.

The portable acetylene cutting and welding torch is without question the most valuable piece of equipment in the electrical and mechanical repair shop. It can be used on more jobs than any other tool and is also the most convenient and flexible in reaching an ordinarily inaccessible location.

* * * *

H. D. Fisher, Plant Engineer, New Haven Pulp & Board Co., New Haven, Conn. *Question 1.*—We do not have a very formal organization, as we have a comparatively small plant. Our plant is arranged so as to form two practically separate paper mills, in each of which we have a millwright who is responsible for the upkeep of the equipment, with a total of four helpers who are distributed as needed. For general service for both mills we have a machinist, an electrician who has a helper, when needed, a steamfitter with one to three helpers according to the amount of work in progress and a bricklayer for boiler wall maintenance and general building repairs. Our reason for carrying such a variety of help is that paper mill operation is continuous, 24 hr. a day, so that it is necessary to have sufficient men available to make repairs while the machines are shut down. In order to employ them economically during the week and also have them on hand in case of accident or emergency, they do most of the minor alterations and construction work and also make up as many repair parts for machines as possible.

Question 2.—Periodic, careful inspection and a policy of replacing material before it gets to the breaking point has done the most to reduce repair and upkeep costs.

Usually some parts can be bushed or renewed and kept for spares, while if left alone until breakage ensues they are junk. Probably our most remunerative single change was driving the compensating shaft winder by a motor instead of directly from the paper machine engine, and replacing the cast-iron pinions of the differential mechanism with steel pinions. Formerly at times we broke three or four pinions a week, costing $5 to $10 apiece, but since using steel pinions, and a motor drive, which gives a smoother, less jerky pull, we have lost only one steel pinion. Trouble with the main cast-iron gears, which we thought possible with the greater stresses transmitted through the steel pinions, has not materialized. We have also saved about half of a man's time replacing gears. Just at present we are having considerable trouble with a 24-in. vertical belt drive, having 20-ft. vertical centers, and 3-ft. horizontal centers. This belt, which runs on a 46-in. upper pulley turning at 150 r.p.m. and an 84-in. lower pulley having a speed of 82 r.p.m., and transmits 100 to 125 hp., gives us more trouble than any one piece of apparatus. I am using a rubber belt at present but expect to substitute an endless leather belt.

Question 3.—We have replaced several small steam turbines driving heating fans with variable-speed, slip-ring motors, with considerable economy and convenience, as the motors require less attention than the small turbines.

Question 5.—Our principal requirements are power and speed, so that our most-used portable testing equipment is an Esterline graphic wattmeter with universal transformers and a recording tachometer. We also have and use a steam flow meter and pressure recorder for special tests.

Question 6.—Our repair shop equipment is exclusively mechanical as with about 50 motors aggregating 3,000 hp. in service, we average only about three rewinding jobs a year, and with the excellent local facilities we cannot afford to try to do such work.

* * * *

R. N. Vining, Electrical Engineer, Detroit Seamless Steel Tubes Co., Detroit, Mich. *Question 1.*—Successful maintenance of electrical equipment consists essentially of three items: First, and most important, systematic inspection with an effort to avoid breakdowns; second, trouble shooting and repairs; third, operation, including oiling, cleaning, switching, etc.

The number of men required in the maintenance force is more exactly determined in the reverse order. The

power house and each substation require an operator to start, stop and care for the machines. It is seldom possible to use one man for more than one station on account of the relative locations. Each station is generally of such size that one man can handle the electrical equipment. The maintenance electricians answer all trouble calls by locating the trouble and repairing the equipment, if practical, without removing it from the job. These men are generally grouped in pairs, an electrician and helper forming a unit. The repair shop men do the motor winding, switch and controller overhauling, restacking of grids and other general repair work. The maintenance electricians frequently have time during the day to make inspections over some section of the factory. This inspection is arranged as closely as possible to cover weekly all motors in the mill as to general inspection, operation, load conditions, and condition of motor and control both electrically and mechanically. As often as possible air gaps are checked for bearing wear and equipment is checked for grounds and insulation resistance.

Question 2.—With a.c. motors, our largest savings in maintenance costs have been made by frequent checks of the bearing wear. The inspector is supplied with a thickness gauge consisting of seven leaves. These feelers are in thicknesses of 8, 10, 12, 14, 15, 16, and 18 thousandths and are each 12 in. long. The gage is of General Electric Company manufacture and known as Cat. No. 2155371G1. General tests of insulation have also shown marked savings.

Question 3.—We have experienced considerable trouble with a group of multi-speed, three-phase, a.c. motors operating cut-off machines. There are so many leads, 14 in all, and controller connections, 18 fingers, that we frequently have single-phase operation. Direct-current motors are better adapted to this service.

Question 4.—One of the most important improvements in the last few years, in the way of protection to the smaller motors, is the development of the thermal cutout relay. These relays have proven particularly effective on the cut-off drive just mentioned.

Question 5.—Our most valuable testing equipment is: an a.c. ammeter with multiple-tap, slip-on transformer having ranges from 5 to 400 amp.; a d.c. millivoltmeter with shunts of 10-, 100-, 200-, 500-, and 1,000-amp. capacity for measuring current; and a multiple-leaf thickness gage for measuring air gaps. A Megger is also particularly valuable for insulation testing. A portable graphic millivoltmeter used with shunts in measuring d.c. current, together with a multiplier for d.c. voltage and a magneto driven from the motor under test as a means of recording speed, are also of great help.

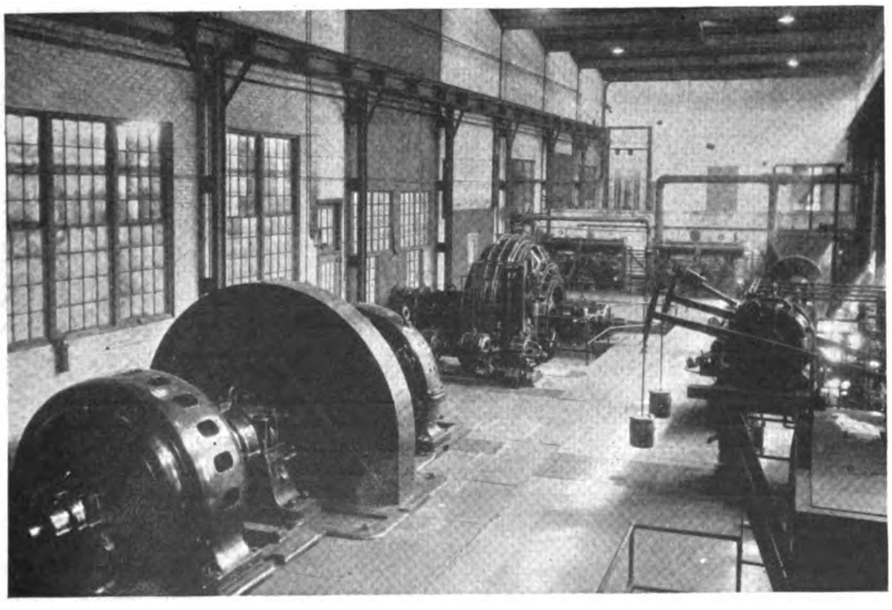
Question 6.—One of our recent additions to the repair shop is a standard gasoline torch fitted with a special air connection on the back of the burner. A small copper tube acts as a syphon to the gasoline section. By this means a spray of gasoline under pressure can be applied to armatures and other equipment for cleaning purposes, with a considerable saving in time and expense over previous methods used.

* * * *

H. E. Stafford, Electrical Engineer, Provincial Paper Mills, Port Arthur, Que., Can. *Question 1.*—The plant with which the writer is associated has a connected load of approximately 7,400 hp. in a.c. motors and 350 hp. in. d.c. motors. We have 155 motors of ½ to 1,400 hp. capacity.

These motors are inspected once every 24 hr. Each motor is numbered and a card, shown on page 72 is placed at each motor. The inspector checks off on this card the different items inspected and at the end of two weeks the card is brought into the office. This plan insures that the inspector gets to each motor and being at the motor makes it easy to look it over. This system has worked out very well and the daily inspection brings to light various troubles that would otherwise cause a shutdown were they not detected early.

Operating delays on equipment of this nature are being prevented by thorough, systematic inspection.
The maintenance methods used in the Blooming Mill Substation of Follansbee Bros. Co., Toronto, O., are given in J. C. Murray's comments on page 67.



Question 2.—A power survey was made of the plant last February and March, and a small number of changes were made. Due to increasing the number of agitator blades and the size of pump impellors some of the motors were considerably overloaded, while others had their load reduced. In one or two cases it was possible to switch motors, as the speeds were identical and the horse-power was right for the load. In other cases it was necessary to use reduction gears, while in two cases the speed and horsepower of the motors were changed.

In order to be insured against shutdowns of motors of different speeds and ratings, but of the same frame size, the writer re-arranged a stator to develop two speeds, 900 and 1,800 r.p.m. and another stator of the same frame size for speeds of 600 and 1,200 r.p.m. By making a few changes in the sizes of pulleys, these stators may be used to replace the stators of 25 motors of 5 to 25 hp. capacity, with speeds ranging from 600 to 1,800 r.p.m. Probably this is the most outstanding convenience in the electrical department of this plant, as an outlay of about $500 insured 25 motors against shutdown longer than the time necessary to change stators.

Question 3.—In a pulp and paper mill, water is the worst enemy of electrical equipment. To safeguard against water from hose nozzles, bursting pipes, and overflowing stock pits, the majority of motors and starting equipment is covered with metal housings properly ventilated and accessible for oiling and inspection.

Considerable trouble was encountered with the starting resistances of d.c. motors burning out, due to the controller handles being left on some of the intermediate steps. By replacing all resistances so affected, by others of greater carrying capacity, it is possible to leave the controller at any step for an indefinite period without any damage to equipment. Considerable time has been saved since the installation of these resistances and the cost of replacements saved, has more than paid for their initial cost.

Neglect and carelessness may be said to be the contributing cause of 90 per cent of equipment failures. Neglect of bearings, using too much or too little oil or the absence of the use of feelers for air gap measurement are contributing causes of motor failures. Overfusing and tying-in of starter handles are contributing causes of not only motor failures but controller failures as well.

Question 4.—There have been no radical changes in the mechanical and electrical drives of this plant of late, but provisions have been made for changing the drive on two beaters from belt to silent chain. The space occupied will be much less, the drive more positive and replacements fewer, besides better operating conditions.

Question 5.—The apparatus for load testing consists of a panel-mounted graphic wattmeter, graphic kva. meter,

integrating watt-hour meter, indicating wattmeter, indicating power factor meter, voltmeter and ammeters. The portable instruments consist of three current transformers, two potential transformers, a power factor meter, wattmeter, voltmeter and ammeter. For insulation testing, an Evershed megger is used. All the above apparatus is used at regular intervals for a general check, or as often as emergency cases warrant.

Question 6.—The electrical repair shop is equipped with a portable winding table and chain block, a portable air compressor for blowing out motors and running small air tools, an impregnating tank for small and medium-sized motors, an electric oven for baking and drying motors and equipment, an emery wheel, complete set of pipe fitting tools and commutator stones for all sizes of machines in the plant. The air compressor mentioned above can be taken to any part of the plant. The baking oven is of 5-kw. capacity, built up of Cutler-Hammer space heaters and provided with a portable hood.

Probably the greatest saving in time and equipment has been made by the portable air compressor which, equipped with 250 ft. of three-conductor cable and 150 ft. of air hose, can reach the remotest and most inaccessible motor in the shortest possible time.

* * * *

W. W. Lankton, Assistant Electrical Engineer, Detroit Copper and Brass Rolling Mills, Detroit, Mich. *Question 1.*—The electrical work in our plant is handled by a crew of 19 men exclusive of crane operators, of which there are seven, and one girl for office work. This includes the Electrical Engineer and assistant, two construction journeymen and two helpers, five maintenance men, one for each mill and two for night duty, one armature winder and helper, three repair shop men, one of whom has charge of all instruments, meter repair and testing, and one stock man.

The most effective distribution of maintenance work that we have found so far is to make one man directly responsible for all electrical maintenance in one section of the plant. He has his headquarters at the substation in his section and is thus available for all trouble shooting or minor repairs. If extra help is needed a telephone call to the shop brings a repair man.

This direct fixing of responsibility, in connection with daily written reports from each maintenance man to the office of the Electrical Department, produces excellent results. These reports are not intended to be lists of the number of hours spent on different kinds of work, but include delays to productive machinery, with length of time thereof and causes; also, all unusual troubles, or ordinary trouble which is constantly recurring and might be remedied by some change in apparatus or otherwise, and in fact any information of interest.

Question 2.—Large savings in maintenance costs have been made by the installation of overload relays on all motors. These have reduced our trouble calls by 60 per cent.

Fused switches are used for line protection and all starting units are made up with non-fused disconnecting switches of the safety type. In the case of phase-wound motors in sizes up to 100 hp., all the starting equipment is assembled in one frame as a unit. The disconnecting switch, oil switch with overload relays, controller and starting resistor are all mounted compactly on a pipe frame with base made up of channel iron.

We have used the standard types of renewable fuses since these were first placed on the market and have found them very satisfactory when properly refilled. Our practice has been to have all blown fuses brought to the shop where they are thoroughly cleaned and refilled by one man. After filling, the ferrules or contact blades are polished on a small buffing wheel and the fuses are placed in racks marked with the different sizes. The current rating is also stamped on all shells to avoid any mistakes in size.

Six steam engines ranging in size from 300 to 1,500 hp. have been replaced by electrical drives in our plant since 1918. One of the latest and possibly the most interesting of these installations is partially shown in the illustration on page 73. The rope drive was on a hot copper rod mill intermediate and run-down drive and was replaced by a two-motor and Falk herringbone gear drive, as shown under construction in the illustration at the left. The motors of 400-and 200-hp. rating, are connected to opposite ends of the same shaft and either one or both may be run according to the load requirements. The controls are interlocked so that the 400-hp. motor is always started first and when both are running either may be tripped off as desired. One great advantage of this arrangement over a single motor drive is that better power factor and efficiency conditions are obtainable due to the fact that the motors can be run at or near full load, under conditions of light load on the mill, the mill load varying with the size and shape of the bars.

The break-down unit of this mill, which was driven by the same engine, was replaced by a single 300-hp., phase-wound motor with Falk gears and flywheel. A small amount of fixed resistance made up of flat bars of nickel silver is connected in the secondary leads of this motor to enable the flywheel to absorb the peak loads of short duration.

Question 5.—A fairly complete line of testing equipment is essential in any large industrial plant, but the two instruments which have been of the most outstanding value are the curve-drawing wattmeter for study of load conditions on all sizes of motors, and the Megger for testing insulation resistance of large generator and motor windings, and high-voltage, lead-covered cables, particularly at the time of installation or repair.

The aforementioned graphic wattmeter is arranged to be direct reading on all sizes of motors. This is accomplished by means of one pair of plug-type current transformers which are adjustable to ratios of 25/5, 50/5, and 100/5 amp. and one pair of 1,000/5 split-type current transformers which may be adjusted for ratios of 500/5 or 250/5 by looping two or four turns of cable through them for the primary. The direct reading feature is obtained by a series of chart rolls, one corresponding to each transformer ratio. This direct reading of the chart without the use of multipliers is of inestimable value when discussing load conditions, etc., with company officials,

This motor inspector's report, covering a period of two weeks, is used in a paper mill.

Details regarding the use of this form are given in H. E. Stafford's comments on page 71.

2 Weeks Ending Dec 19. 1925 — Form 298

ELECTRICAL DEPARTMENT

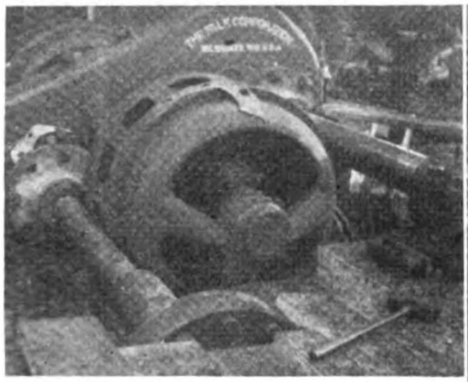
DAILY

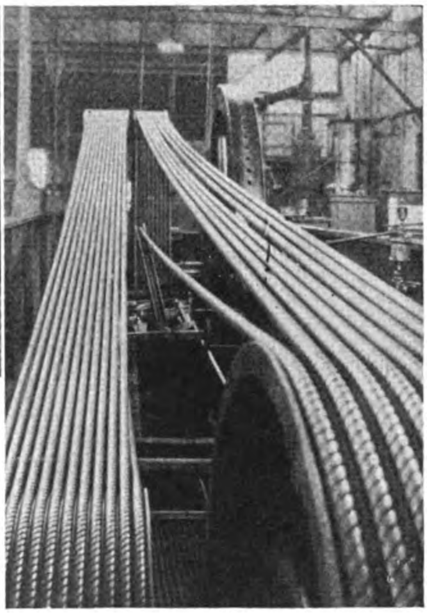
INSPECTION CARD — Motor No. 148

	A. M. 7	8	9	10	11	12	P. M. 1	2	3	4	5	6	Condition	Cleaned	Oiled	Inspector
Monday								X					Good	Yes	Yes	Rickard
Tuesday								X					"	No	No	Rickard
Wednesday								X					"	"	Yes	Rickard
Thursday								X					Bearing in bad condition		Yes	Rickard
Friday								X						no	No	Rickard
Saturday								X						"	Yes	Rickard
Monday								X						Yes	Yes	Skippon
Tuesday								X						No	No	Skippon
Wednesday								X						"	Yes	Skippon
Thursday								X						"	No	Skippon
Friday								X						"	Yes	Skippon
Saturday								X						"	No	Skippon
								X								

Foreman's Semi-Monthly Report Pulley end bearing changed Thur
Motor in good condition

J. Weckstrom Foreman.





Change from rope drive to geared motor drive resulted in marked economies in a hot copper rod mill. This mill in the plant of the Detroit Copper & Brass Rolling Mills, Detroit, Mich., was originally driven by a steam engine through a rope drive, as shown in the illustration at the right. This was replaced by a Falk reduction gear driven by two wound-rotor induction motors connected to the same shaft, as shown in the left-hand illustration.

as the data when presented in connection with the chart are thereby made more convincing.

The curve drawing meter also has a peculiar psychological effect. Whenever it is being set up on a motor-driven machine, the operator almost invariably goes over his machine very carefully, oiling all parts and looking over belt and pulleys. In some cases of overloads, the trouble is immediately rectified in this manner.

Question 6.—In our winding department we are using the Segur coil forming and taping machines and a coil winder of the Segur type; also a portable Franklin crane for handling motors and heavy parts. All new windings are dipped or sprayed and baked in an electrically-heated oven which we have constructed ourselves. The latest valued addition to our equipment in this department is an oxy-acetylene lead-burning torch for use in soldering coil clips, etc. This is particularly valuable for use on the coil clips of large rotors.

* * * *

Lyle Hendricks, District Electrician, Pickands, Mather & Co., Hibbing, Minn. *Question 1.*—The supervision of the electrical and mechanical equipment at all of our properties comes under the jurisdiction of the Chief Mechanical Engineer at our general office in Duluth. This includes twenty-five iron mines in Minnesota, Wisconsin, and Michigan. District Electricians or Master Mechanics are directly in charge of their respective equipment in the different districts into which this territory is divided. One or more mine electricians and helpers are located at each of the mines having sufficient electrical machinery to warrant their employment. These men form a district gang, and are moved from mine to mine on the larger jobs. The fact that the work is seasonal, having an operating season of only six months at most of the mines, makes it very difficult to form a permanent organization.

Questions 2, 3 and 4.—The electrification of the underground mines has been very largely carried out and has shown important savings in operating costs. Probably the most important of the recent changes in mining methods has been the introduction of slusher loading to replace hand shoveling. Both air and electric tuggers are used, but as the power cost ratio is about 18 to 1 in favor of the electric, the air tugger is fast becoming obsolete. Both the haulage and slushing equipment are handled by inexperienced labor and require considerable maintenance. Trolley and light wiring underground require a great deal of attention, due to the heavy caving conditions.

The electrification of the open pits is of a more recent nature but bids fair to be more important than that of the underground mines. Electric shovels of all sizes have been introduced and are proving superior to the steam shovel, both in point of economy of operation and reliability of service. This applies especially to the large revolving shovels. Electric blast hole drills of the well-rig type are generally used and give very good service. Their superiority is especially noticed during the winter. Power for both electric shovels and drills is provided through rubber-covered cables, and these cables receive very severe service. Electric locomotives are used at some of the mines and one pit is completely electrified. Crushing and washing plants are used at some of the mines and in all cases are completely electrified. Practically all open pit machinery requires a great deal of maintenance due to overloads, abuse, exposure, etc., and quick repairs are essential.

Question 5.—For the maintenance of our electrical apparatus we have the following equipment; oil testing transformer, portable "Meg" insulation tester, rotating standard watthour-meter indicating ammeters and voltmeters and the necessary instrument transformers. Transformer oil is tested yearly, and the insulation resistance of the larger electrical apparatus is measured just before the spring operating season. Watt-hour meters are tested every year and the resistance of pipe-driven grounds is measured during the dry season.

Question 6.—At present we do not have a fully equipped district electric shop, but have small shops at the mines and repair work is carried on in connection with the machine shops.

* * * *

A. Hauswald, Chief Electrician, De La Vergne Machine Co., New York, N. Y. *Question 1.*—The company with which I am associated, builds refrigerating machines, installs ice plants, and builds and erects oil engines of the Diesel type, made in sizes from 40 hp. to 1,000 hp. This company employs 350 men in the shops.

The maintenance work in the Electrical Department is taken care of by three electricians and myself. Rewinding of armatures is let out on contract, as it does not pay us to do this class of work; we seldom have a breakdown of this kind.

We generate our own power and deliver about 1,000,000 kw.-hr. yearly to the shops and offices for light, heat and power.

Question 2.—In the past two years I have made several changes to the electrical equipment, which have resulted in a saving of time and money. For instance, I have a clock and periodograph time-recording system which were operated from a 48-volt storage battery. This battery also furnished current for bell systems and a watchman clock system. I revamped the various circuits by re-connecting them from a straight series system to a parallel-series system. By doing so, I eliminated one 24-volt storage battery, plus half of the time that would be spent in locating trouble on the straight series system when an open circuit occurred.

Question 4.—We have installed two new 15-ton Niles cranes during the past two years, one in our erecting shop, where engines are set up for test. Now, to speed up this work, we have two cranes operating on the same rails in the one shop. None of the mechanics on the test floor has to wait for crane service.

Another 15-ton crane was installed in the yard where engine frames and other castings are stored.

A new 4-ton electric elevator was installed to replace an old 2-ton hydraulic elevator which was in service some 35 years. The new electric elevator is of higher speed, which also speeds up production.

Several very old motors were scrapped, due to the fact that the upkeep was high, because they were troublesome and delayed production and increased maintenance costs. These were replaced by spare motors which I had on hand and which were in better shape than the old ones.

Question 5.—I have several graphic meters, voltmeters, ammeters, all of which are of the direct-current type, and are used for testing. We also have a Standco Megohmmeter which is used to check insulation resistance and can also be used as a voltmeter. I find this latter instrument a necessity for measuring the insulation resistance of motors, generators, and power circuits.

A. B. Adams, Electrician, Elgin National Watch Company, Elgin, Ill. *Question 1.*—The general formula for successful and economical electrical maintenance in a watch factory is in no way different from that of any other manufacturing institution. While it is true that the apparatus may not be as complicated or in such large units as in steel mills, automobile factories, and the like, certain rules must be laid down by the management and rigidly enforced, to lessen the personal injury and fire hazards.

Notices are posted in conspicuous places in every department in this factory warning the employees not to meddle or attempt to make any electrical repairs; they are forbidden even to take a shade from its holder—this is a rather drastic rule, but it brings in 100 per cent interest each year.

Our power plant furnishes current for about 8,000 lamps and about 300 a.c. motors ranging in size from 1/30 to 175 hp. About 95 per cent of these motors are of the three-phase, 60-cycle induction type. All new motors are taken apart and given a rigid inspection, the rotors are tested for poise and loose bars, and the oil grooves in the boxes are enlarged in many cases. Any unusual noises in operating motors are reported and depth gages are used to find if this is due to improper clearance between the rotor and armature. A difference of 0.01 in. in gap over the original measurement is all that is permissible, and new bronze boxes are installed when this value is exceeded. Wattmeter readings are made when motors are put in commission, to insure that they are not overloaded.

Question 2.—Due to the oil used, in 15 years there have been no frozen boxes, and lubricating troubles are a thing of the past. All motors are oiled each week and where possible oil gages have been installed to show that the proper level is maintained. Nearly all motors are hung upside down and fastened to the ceiling beams; the use of portable hoisting elevators has made the installation of them a simple and easy job. Idlers are installed wherever possible and the ceilings over the driving line shafts have been recessed to permit the use of 36-in. pulleys. This makes possible the use of a larger motor pulley, and they are made wide to insure good traction. A few years ago many motors of the double-drive type with 4-in. pulleys were in use, but these have been altered to a single drive, as it was found difficult to get two belts on the same size pulleys, and connected to the same lineshaft, to pull alike.

Question 3.—In this plant there are in operation hundreds of automatic machines and lathes, most of which are push-button controlled. Each machine has a tell-tale lamp which lights when the machine automatically shuts down on account of running out of stock, broken drills, or other troubles. Nearly all of these machines are piped for oil and compressed air, and the room as a result is heavy with vapor. The oil in time eats all the insulation from the wires and leaves just the outside linen braid for protection. There were several small fires as a result of grounds and short-circuits, and many calls for service. At the present time all machines are wired with white-braid Underwriters' wire, which is impervious to oil, and shutdowns have been reduced to a minimum. On many of these machines a very high speed is maintained and a very small chip is turned from the stock. These chips resemble particles of fine emery dust. This dust would mix with the oil and work into the bearings, causing continual repairs to spindles and revolving heads. To correct this, all oil is now run through a succession of felt filters and over a huge electromagnet measuring about 8 ft. in length and 12 in. wide. At this point the steel chips stop and the clear oil is pumped back to the machines.

Another disturbing element to the maintenance man is the burning out of immersion coils which are used to heat oil to a temperature up to 475 deg. F. Thermometers were placed in the oil kettles and the operator was supposed to pull the switch when the high mark was reached. Sometimes he did, and again he did not until the oil was almost at the flashing point. There is no guesswork now; automatic relays and thermostats regulate the heat. The cost of this apparatus ran into money, but it pays big dividends.

One of our most persistent troubles was the adjustment of the department gongs, which ring six times each day. These were continually needing adjustments. Alternating-current siren horns have been substituted and after four years of service none has yet been taken down.

Starting compensators with automatic no-voltage release have been a great help. Most of the automatic machines require a uniform speed for successful operation, and functioning of an overload relay would prevent broken drills and cutters and hours of labor resetting new ones.

Owing to the smallness of most of the work throughout the factory, each machine inspector or operator requires an individual light or two. General illumination is used only in the offices. By a special ruling of the Underwriters, drop cords with adjustable weights and pulleys are in general use. The weight cords are all double-tied and wired against untying.

The maintenance force consists of four men who do all the repairs and new wiring for lights and motors on Company property. During a period of 20 years on the job, the writer knows of no shutdown or loss of time that could be attributed to poor or careless work, and no employee has ever been seriously injured.

* * * *

Nathaniel H. Case, Chief Electrician, Wyckoff Drawn Steel Co., Ambridge, Pa. *Question 1.*—We have installed in our plant 85 a.c. motors ranging in size from ½ to 100 hp., 30 d.c. motors ranging from 1 to 70 hp., 16 electrically operated 2- and 3-ton hoists, and one 10-ton crane. As our plant is still expanding, construction, maintenance, and repairs are handled by the same men.

Question 2.—Data cards are kept on all repair jobs, such as changing oil in bearings, auto-starters, compensators, replacing bearings, brushes, new parts on hoists, cables, etc. A glance through the card index may show a certain hoist using more cables than others. An examination of the drum on this hoist may prove that the grooves have become worn to such an extent that the edges are very sharp causing a shearing motion, which cuts the outside cable strands, causing the cable to wear out much faster than necessary. Under these conditions we find our index a guide against bad break downs, and also a money saving scheme on repairs.

Data cards are also kept on chains, showing the location of the chains, when annealed, repaired, etc.

Much expense has been saved in repairs to motors by cutting out defective coils from d.c. armatures and also stator coils from a.c. motors. We have been operating a 10-hp., 440-volt a.c. motor for over a year with seven coils cut out, and it is still going good.

By the use of commutator stones we have been able, by touching up our commutators now and then, to operate our commutator and slip ring motors for a period of six years without having one turned in the lathe, which we all understand takes a considerable amount of life from a commutator. Hence we figure the stones a very good investment.

Question 3.—Our monorail hoists consist of two 3-ton hoists mounted on the same beam, one 10 ft. in front of the other and connected together by means of a steel bar. The trolley motors are connected in series so that both may have the same speed. This outfit was at first operated on the lower flange of a 10-in. I-beam. Due to the sharp curves and the frequency of the trips, the flanges of the I-beam became worn and sharp, which soon cut the flange of the wheels to such an extent that the hoist climbed the beam flange, causing cutting of the side casting and placing the hoist in a position to snap a casting and fall to the floor. This was overcome by placing 16-lb. rails on the lower flange of the beam. Wider flat wheels were installed in place of the bevel track wheels formerly used. This gave us a wider working surface, longer lived wheels, and longer lived track.

Question 5.—We use both a.c. and d.c. portable voltmeters and ammeters for testing individual motors in order to obtain load characteristics of each machine. A record is kept of the different tests showing the load, speed, and the amount of work done under these conditions. It often occurs that a certain amount of work must be done in a certain time which would require pushing the machine. A glance at the data card listed under this machine will show just what the machine will stand. Under these conditions if a machine is loaded to full capacity or over, every one concerned in its operation is aware of the fact and knows it will stand watching. This is, to our knowledge and experience, a much safer and more economical method of operation, than to slam a big load on a machine blindfolded, and then when something breaks it is discovered that the load was too much for the motor.

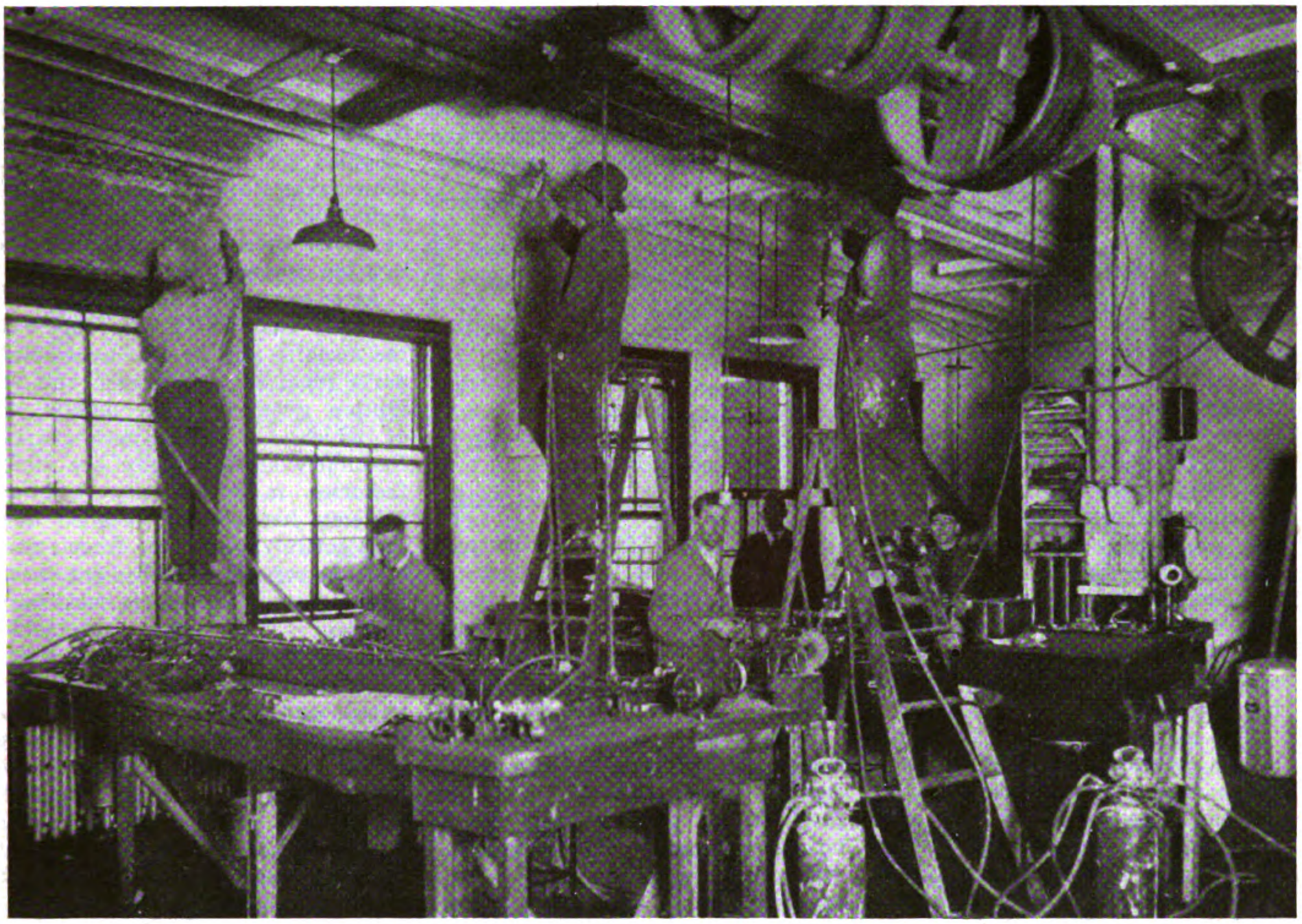


Fig. 1—Refinishing the walls and ceilings will improve their reflecting qualities and increase the effectiveness of the lighting system. Grimy, discolored, or dark-colored walls and ceilings reflect light poorly and give an unattractive appearance to the factory. Painting with light-colored paint greatly improves this situation. In this illustration, paint spray guns are being used to speed up and cut the cost of the painting operation.

How to Get the Most from Your Lighting System

together with a discussion of what better lighting costs, how much better lighting is worth to you, and maintenance methods that will improve faulty lighting conditions in your plant

By ROY A. PALMER
National Lamp Works of General Electric Company, Cleveland, Ohio

COST is usually the basis for the most strenuous objections on the part of the operating executive to installing a new lighting system or revamping the existing installation. However, in spite of the fact that better lighting apparently costs more than poor lighting, a close analysis will almost always prove that poor lighting is really more expensive than good lighting.

The lighting system of a factory should be considered as important as a labor-saving machine, rather than as an expense-building item. When new improvements are brought about in a machine so that through economies in labor and in time, it can be made to pay for itself within a reasonable period, the old machines are promptly discarded in favor of the new machines. Better lighting has demonstrated its effectiveness in increasing production, decreasing accidents, and in many other ways benefitting the factory owner and worker. These benefits are the dividends from an investment in better lighting which more than pay for the added cost.

The cost of lighting is usually compared with the payroll, since wages are one of the major items in production expense and it is possible by this comparison to determine the value of light in aiding production. For example, a worker paid at the rate of 60 cents an hour receives one cent a minute. A 200-watt lamp will provide illumination for the worker and will cost less than 5 cents to operate for a period of 8 hr. If through the day, the worker should lose 5 min. in groping about for tools or material hidden by dark shadows because of poor lighting, the cost of a whole day's light is lost. If, on the other hand, his actions and speed of vision are so increased by better lighting that he is able to turn out 10 per cent more work, the cost of the lighting is paid for many times over. In the nine tests which have been previously mentioned in this series of articles,

the average increase in production resulting from better lighting was 12.2 per cent while the increased cost of lighting averaged 1.96 per cent of the payroll.

Thus we see that if increased production were the only benefit resulting from better lighting, it would pay to equip a plant with the best lighting system obtainable. Fortunately, the reduced number of accidents, less spoilage, improved product, better working conditions and satisfied employees are additional benefits which result from better lighting and which help to justify the added cost. These benefits are obviously difficult to evaluate in dollars and cents, but nevertheless they are worthy of serious consideration. The cost in lost time and in compensation for a single accident which might be caused directly or indirectly by poor lighting would perhaps pay the cost of good lighting for a whole year.

For many years past, there has been a constant rise in living costs, which reached a peak shortly after the war. The cost of light has, however, declined and at the present time it costs less to operate a 100-watt Mazda lamp than it does to burn a wax candle.

The reduction in the cost of light can be attributed to three factors: (1) Reduction in rates for electric energy. (2) Improvements in the efficiency of lamps. (3) Reduction in prices of lamps.

Notwithstanding the fact that the cost of fuel has almost doubled since 1914 and that labor and supplies have increased considerably, the rates for electric energy have remained practically constant since 1914. Previous to this period, there had been a reduction in the rates for electric energy in each year since electric lighting was first used.

Improvements in incandescent lamps have been such that more light is obtained for a given consumption of current. Since in many cases the cost of lamps is, according to the National Electric Light Association, less than 10 per cent of the total bill for electric current, the improvements in the efficiency of a lamp are important. Better manufacturing methods and the greater use of labor saving machinery have brought about a reduction of 37 per cent in the prices of lamps during the past two years.

With the improved efficiency and the low cost of lamps and the low cost of electric energy, artificial light is cheaper now than it has been at any other time. In Fig. 2 is shown how these changes have taken place during the past forty years. In view of the fact that good lighting can now be obtained so cheaply, it should be the duty of every industrial executive to provide lighting systems in his plant which are of the most modern design.

Do Not Let These Items Steal Light in Your Plant

(1) Dirty reflectors and lamps.
(2) Darkened walls and ceilings.
(3) Depreciated lamps.
(4) Empty sockets.
(5) Unobserved burnouts.
(6) Improper size or wrong voltage applied to lamps.

Because we have always built our homes and buildings so as to utilize daylight to a considerable extent, we rarely think that daylight in interiors costs money. In a paper outlining an investigation of the cost of daylight, Messrs. Luckiesh and Holloday showed that in general, daylight costs about the same as electric light. Large window areas and skylights cost more than walls or roofs; heat losses occasioned by glass are sometimes an item of expense; cleaning and repair costs are perhaps the largest expense, while consideration should also be given to the investment in ground area occupied by light courts. All of these factors are chargeable to daylight and hence due weight should be given them when planning the lighting arrangements.

After buying an automobile, it is expected that at various intervals the machine will need to be washed, parts repaired or replaced, and attention given to other details, all of which are called maintenance. Peculiarly enough, there are many factories in which new lighting systems have been installed and then entirely neglected, except, perhaps, to replace a burned-out lamp. The lighting system is not very different from the automobile from the standpoint of maintenance, except that when the motor is neglected and refuses to work the whole car is useless, but the lighting system, even though neglected, works faithfully in part at least. Burned-out lamps occur only in spots throughout the plant and do not materially affect the remainder of the lighting system.

But there are other factors which enter into the maintenance of lighting systems that rob the factory of the benefits which good lighting systems contribute. The loss of

Cleaning Schedules for Lighting Fixtures Used Under Different Conditions

Where direct lighting systems are used, i. e., where there are no reflecting or diffusing surfaces concave upward to invite dirt accumulation, the interval of cleaning should be about as follows:

Characteristic of Location	Interval in Days If Units Are Wiped Out*	Interval in Days If Units Are Thoroughly Washed
Very Dirty	3	5
Dirty	7	10
Average	15	20
Clean	30	40

Where open semi-indirect or totally indirect units are used:

Characteristic of Location	Interval in Days If Units Are Wiped Out	Interval in Days If Units Are Thoroughly Washed
Dirty	5	7
Average	10	15
Clean	20	30

*Washing every third or fourth interval assumed.

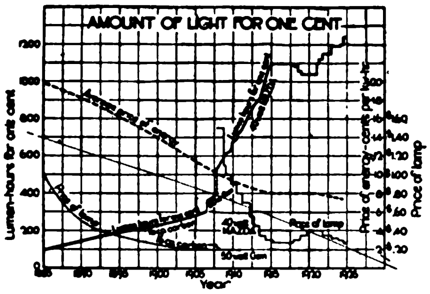


Fig. 2—The cost of electric light has shown a steady decrease since its inception forty years ago.

As may be seen by the solid line the amount of light that can be bought for one cent has increased until it now stands at 1,240 lumen-hours for a 40-watt Mazda lamp. The dash line shows the decrease in the cost of energy, while the dotted line shows the decrease in the cost of lamps.

these benefits constitutes a loss in dollars and cents and, therefore, maintenance can rightfully be considered as part of the cost of lighting.

The fact that better lighting increases production, decreases accidents, spoilage, and labor turnover, indicates that the difference between good lighting and inferior lighting is of more than ordinary importance. It indicates further that the operating executive cannot afford to permit the illumination to be wasted through neglect in keeping the lighting units clean and proper lamps supplied. Experience has shown that one-fourth or even one-half of the light which the illumination system is capable of giving is sometimes wasted because of lack of proper maintenance.

The common neglect in the care of lighting systems can be attributed to the fact that few realize how rapidly and to what extent dirt and dust cut down the output of lighting systems. Fig. 3 shows in graphic form how dust and dirt affect the light output of a reflector. The accumulation of dust upon lighting units is so gradual that it is impossible to discern how materially the illumination is affected from one week to the next. The character of the surroundings will, of course, determine the rapidity with which the lighting is affected. In relatively favorable locations where there is not an excessive amount of smoke and dust, there will be a depreciation of from 10 to 25 per cent in four weeks' time. In excessively dirty locations the depreciation may be as high as 40 per cent in the same length of time. The use of a foot-candle meter will assist in determining when there is need for giving careful attention to the lighting system.

The amount of light that is received at the work is dependent to some extent upon the reflecting power of the walls and ceilings. When dirt and dust have darkened them, less light is reflected and consequently the illumination upon the work is reduced. The lost light due to darkened walls and ceilings can be restored by refinishing them with a flat white or very light, cream colored paint.

Fig. 4 shows the results that were obtained in three investigations that showed failure to observe simple maintenance requirements.

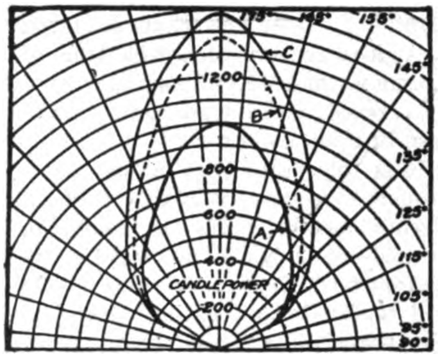


Fig. 3—How dust and dirt affect the light output of a reflector.

Curve *A* shows the light output in candlepower of the reflector when dirty. When merely wiped out the lighting was increased greatly as shown at *B*. After the reflector was thoroughly washed the output was as shown at *C*, which is nearly double that shown at *A*.

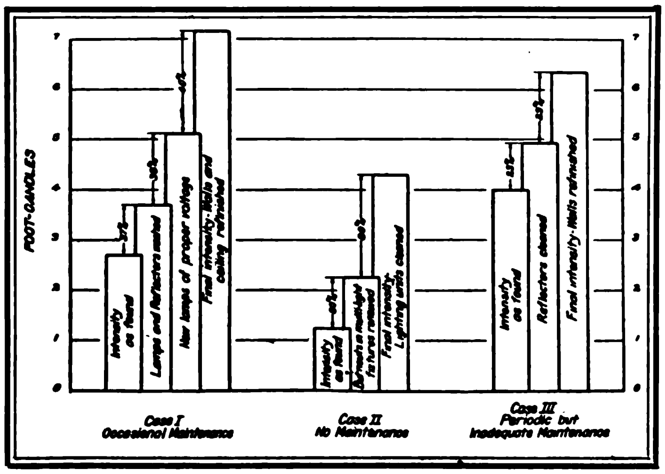
The use of an air brush or paint spray as shown in Fig. 1 will greatly speed up the work of refinishing walls and ceilings.

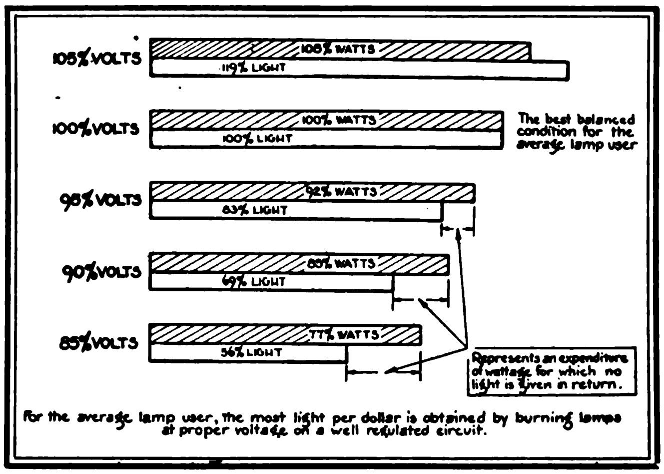
When it is appreciated that the value of light lost through neglect of proper maintenance comprises not only the cost of the energy, but also a loss in efficiency on the part of the workers and a lowered output of the entire plant in general, it is obvious that the slight cost of regular attention to the lighting system is indeed relatively small. It is advisable that a reliable employe be designated to check up regularly on the lighting system according to a definite schedule. Merely wiping out the unit will not always accomplish the desired result. Experience has shown that wiping out a unit results in only about two-thirds the increase in light that is produced by a thorough washing with soap and water. A schedule of inspection periods recommended for different operating conditions is given in the table on page 76.

The cost of maintenance will, of course, vary with the size of the

Figs. 4 and 5—Some of the things to check when attempting to improve your lighting.

Fig. 4 shows the results obtained from three tests made with a foot-candle meter in three different plants. In each case there are given the results obtained after replacing worn out or wrong voltage lamps, and after refinishing walls and ceilings. Fig. 5 shows the effect of burning lamps over and under rated voltage. Over-voltage shortens the lamp life considerably, while operating the lamps at under-voltage decreases the light output as well as lowering the lamp efficiency, although it does increase the lamp life. For the average user the best condition is obtained when the lamps are burned at rated voltage.





plant. In a plant that is large enough to require the entire time of one man, the cost of cleaning should not exceed 3 cents per unit in the case of open reflectors.

It is important that lamps of the proper size and voltage be used. Errors usually occur in replacing burned-out lamps. Labeling the reflectors with the proper size of lamp will assist in preventing lamps of the wrong size from being used, while the measuring of the line voltage with a voltmeter and care in ordering lamps to correspond with that voltage will guard against obtaining lamps of improper voltage rating.

Incandescent lamps are rated for a given light output, when operated at the voltage indicated on the label. If the lamp is burned at a higher voltage, a short life will result; if operated at a lower voltage, it will not give the proper amount of light. It is, therefore, important that the voltage rating of the lamp and line correspond, in order that the highest all-around efficiency be obtained. Fig. 5 shows in graphic form the results obtained through the use of overvoltage and undervoltage on Mazda lamps.

In many factories, the units may be mounted at such height that it is somewhat difficult to reach them for cleaning. In such cases, it is well to install the unit in such a way that it can readily be detached. An extra unit already cleaned should be provided to replace the dirty unit which can be removed to the floor for washing. Such an arrangement will be more convenient and safe and will not hinder workmen because of obstructing ladders or lack of light for doing the work.

There is also equipment on the market which disconnects the lighting unit from the power supply and permits the units to be lowered to the floor by means of a rope and pulley. This method is very convenient and is desirable for many locations. It insures frequent and adequate cleaning and at the same time provides absolute safety to the man doing the cleaning, for the man is on the ground instead of on a ladder; also the lighting unit is dead, thereby preventing danger from shock.

Relations Existing Between the Motor and Its Overload Protection

By C. W. KUHN

Development Engineer. The Cutler-Hammer Mfg. Co., Milwaukee, Wis.

PROTECTIVE devices play an important part in motor applications. In these days of fighting to keep down overhead costs, protective devices must prevent shutdowns caused by burned-out or damaged motors due to injurious overloads.

On the other hand, many of the evils of over-motoring in the past, may be attributed to the desire to guard against motor overloads. Obviously, it is not economical to use a motor larger than is actually required by the normal load, merely to make certain that overloads will not occur. It is quite objectionable to use a larger motor than necessary, both because of the initial investment and because of the increased operating cost. The size of motor for a given load can be reduced if the motor is protected under all conditions of load and the overload does not trip until the motor is in actual danger. This has created a demand for a long inverse-time-element overload. The need for this type of overload device has been increased due to the growing practice of throwing squirrel-cage motors across the line. In many cases it is necessary to start considerable load with these motors and it is essential that protection be given during the starting period.

A realization of these conditions has resulted in the development of better motor protective devices, which make it possible to use smaller motors without too frequent tripping of the overload. As heating is the chief limiting factor which determines the load a motor can carry, the new protective devices are of the thermal overload type.

Thermal overload devices may be divided into two types: the thermal fuse type and the relay type. The fuse type is limited to non-adjustable devices. Change in current rating, therefore, occurs in steps which may not always fit the specific motor for which they are used. This would be practically impossible, as various motors of the same rating differ in their full-load current requirements. The thermal fuse type is also at a disadvantage where frequent tripping may be expected.

There are two kinds of thermal overload relays: one is adjustable, while the other is non-adjustable. The non-adjustable relay has the same limitations regarding the motor current rating as the thermal fuse. Any inaccuracies which cause the device to trip at a lower current than that for which it is rated, may lead to the choice of a protective device of higher rating.

The adjustable relays can be divided into three general divisions according to their principle of operation. These divisions are: expansion of metal, bi-metallic, and change of state.

It is well known that the expansion of metals is small per unit of length. Protective devices utilizing this principle, therefore, require considerable multiplication of movement of the actuating element.

The bi-metallic relays utilize the expansion of metal in a somewhat different way. Bi-metallic metal consists of two different metals, welded together. When the temperature of bi-metallic metal is changed, it curves over to that side having the lower co-efficient of expansion. However, bi-metallic metal is not capable of doing much work; hence, friction may be a cause of inaccuracy in this type.

The third division of thermal relay depends upon change of state for its operation and reduces to a minimum the one great cause of error in thermal devices; namely, temperature. These devices are of two general classes: Those which operate due to a change from liquid to gas and those which operate due to a change from solid to liquid.

The class of protective devices depending for their operation on changing of a material from solid to liquid can readily be made very accurate. If the proper material is used, the tripping temperature is very definite. The greatest error would then be due to the heater. This error, however, is inherent in all thermal devices. The manufacturers of resistance material will furnish material for heaters that varies plus or minus 5 per cent. As the variation in current due to this cause varies with the square root, the probable error is really quite small.

Accuracy is a very important point in connection with overload protection. The more accurate the protective device, the closer the mo-

tor application can be made without danger of burnout or of frequent tripping. In other words, an accurate device permits the use of a smaller motor. The temperature to which a motor heats is another very important factor which must be given thought. Tripping temperature should approximate the danger temperature of the motor. Under these conditions, and with motor and starter subject to the same temperatures, the overload device will compensate for varying ambient temperatures. Protective devices whose tripping temperature is too low, will not permit the motor to carry its maximum safe load when placed in high ambient temperatures. On the other hand, if the tripping temperature is too high, they will permit the motor to burn out under these conditions. With low ambient temperature the reverse is true.

Current adjustment over too wide a range by varying the tripping temperature, is very undesirable for the reason that a variation of 50 per cent in the tripping current would mean a variation in temperature rise of over 2 to 1 as this varies as the square of the current.

As thermal protective devices are being widely used at present, it will be of interest to know which type will be the ultimate design.

Here is an instance where

Keeping a Daily Record of All Equipment Failures

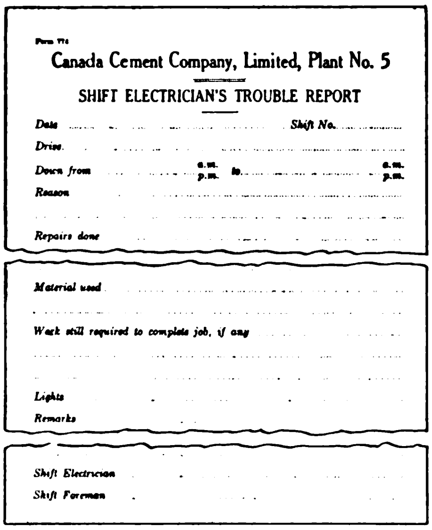
has helped to reduce the number of delays and amount of time lost, by making possible a close check on the causes and frequency of breakdowns

By J. H. GALLANT
Canada Cement Co., Ltd., Belleville, Ontario, Canada

IT IS a fact well known to maintenance men, that oftentimes delays occur much more frequently in one department of a plant than in another. It is also true that interruptions occur much more frequently at certain intervals than at others. However, over an extended period of time, and under normal conditions, the averages for time lost and number of delays are fairly constant.

The price of continuous operation, with a minimum of interruptions, is systematic inspection to forestall possible trouble, frequent comparison of present behavior with averages based on records of past performances, and intelligent analysis of the causes of all interruptions. The method of obtaining data now used at Plant No. 5 of the Canada Cement Co., Ltd., takes little time and does not require a very cumbersome system of records.

With over 100 motors in continuous operation, an attendant or shift electrician is, of course, necessary. His duties are to make regular and systematic inspections, as well as handle whatever repairs can be made by one man, in case of trouble. When more help is required to speed up repairs, the shift electrician may call for assistance; a decision is made according to the judgment of the mill foreman. The shift electrician is supplied with a pad of blank forms, one of which is shown in the accompanying illustration,



Form 776

Canada Cement Company, Limited, Plant No. 5

SHIFT ELECTRICIAN'S TROUBLE REPORT

Date .... Shift No. ....

Drive ....

Down from .... a.m. p.m. to .... a.m. p.m.

Reason ....

Repairs done ....

Material used ....

Work still required to complete job, if any ....

Lights ....

Remarks ....

Shift Electrician ....

Shift Foreman ....

This form is filled in by the electrician in charge at the end of each shift.

One sheet is made out for every delay that occurs; in case there has been no trouble, it is marked O. K. for all equipment. These reports are then turned in to the Plant Electrician who enters the data in a note-book. At the end of the month these reports are tabulated, as shown at the bottom of the following page.

and, if there have been no interruptions, he fills in one form at the end of his shift, reporting that all equipment is operating satisfactorily. If interruptions do occur, he fills out one form for each of these, giving all possible information, especially the reason for the delay, and the repairs required. All of the forms which have been filled in during the previous 24 hr. are handed to the Plant Electrician the next morning.

The Plant Electrician enters the data from these reports in a record book, and notes the duration of and reason for each delay. These data are then tabulated at the end of each month, as shown in the accompanying table. Whenever it is found that interruptions on a certain machine occur more frequently than the average shown by past performance, a special investigation is made with the idea of finding the cause and removing it as soon as possible. Before we started this system the same trouble would often recur several times on a machine before it was realized that there was something radically wrong. By this method and record we have succeeded in cutting down the number and duration of delays about 50 per cent within the past year.

A few concrete examples taken from the accompanying table, which gives our records for the past year, illustrate some of the advantages which have resulted. In October, 1924, we found that the number and duration of interruptions for a generator supplying current for our Hum-mer magnetic vibrators were running up above the average of previous months. On investigating, we found that one of the collector rings was worn down eccentric on one side, apparently due to a soft spot. This caused pitting and sparking to such an extent that the machine had to be stopped often for cleaning and sandpapering the rings. When a new ring was put on, the trouble disappeared and did not show up again for over 6 mo. until a ring again had to be replaced.

The cause of another trouble, which showed up in October and

November of 1924, was not so easily found. We were having too many delays caused by trouble with compensator contacts, both on C. G. E. and Westinghouse compensators. The contacts were of apparently the same quality as always supplied, the oil was clean, and the loads apparently no heavier than usual. As there was no apparent reason for this trouble we decided to watch the men starting the machines and found that the majority of them did not know how to start the motors properly. Under the impression that they were making it easy for the machinery, they would slowly pull over the compensator handle, barely making the contacts touch, and, of course, the resulting arcs caused the damage. An educational campaign among the men stopped the trouble.

Another defect which was also quickly brought to our attention by these records was the bearing failures we experienced in March and the beginning of April, 1925. During these months we were shut down for bearing trouble more than twice as frequently as usual; also, this occasionally resulted in burned-out motors.

As we had been down for repairs in February, and all bearings showing any sign of wear had been changed, we should have been comparatively free from bearing troubles. We finally traced this defect to an inferior quality of babbitt with which most of our spare bearings had been babbitted during this period. As a large number of bearings had been changed during the shut-down this helped to increase the trouble. When good babbitt was used on the bearings their average life again became normal.

Again, during the summer months of 1925 we experienced trouble with the relay mechanism on auto-starters. The wrong kind of oil had been used in the dashpots, with the result that the pistons would sometimes stick, preventing the relays from opening on overloads, and at other times open the contacts just enough for them to arc and burn out. At times the pistons held the contacts open by sticking at the top when the handle was thrown to the running position and accordingly the handle would not stay in this position. This source of delays was overcome by using the right kind of oil.

These are only a few of the troubles which were brought to our attention. No doubt all of these troubles would have been traced down in time, but by knowing the average frequency with which they occurred under normal operation, we were enabled to detect and remedy them much more readily than would otherwise have been the case.

Comparative Cost of Welding and Riveting Steel

ARC welding as a method of fabricating structural steel is not a new departure. For quite a few years it has been used in steel ship construction in the assembly of steel ladders, masts, skylights, funnels, deck stanchions, tanks, etc. Barges and floating targets have also been entirely assembled, and pipe lines, gas holders, oil tanks, small bridges and buildings completely constructed by electric arc welding.

An interesting application of arc welding in the erection of a structural steel building was recently made at Eola, Ill., where the Chicago Burlington and Quincy Railroad erected a 60-ft. by 40-ft. one-story, mill-type building, using scrap steel. The character of the welding is shown in the accompanying illustration. An exact duplicate of this building was also constructed by the riveted method. Data furnished by W. T. Krausch, Engineer of Buildings of the railroad company, shows the following costs:

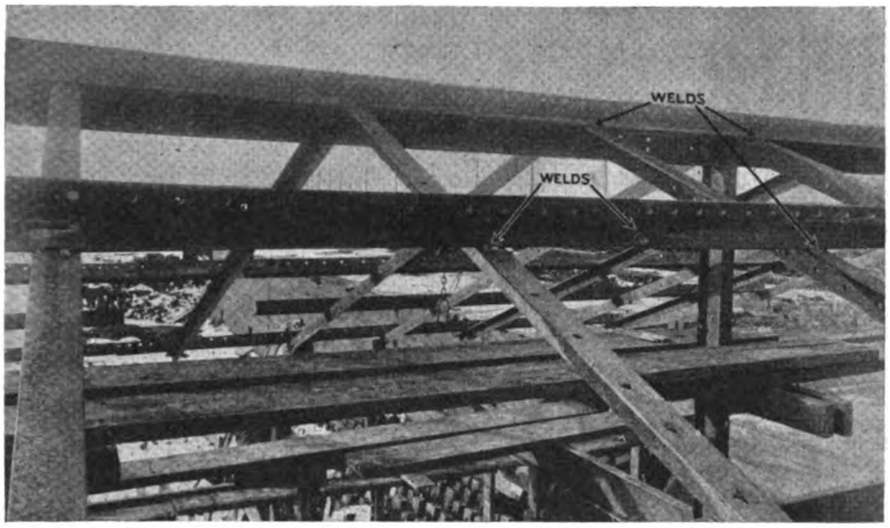
	Welded	Riveted
Preparation cost, including material and shop fabrication	$381.71	$1,000.50
Field erection cost	404.49	339.00
	$786.20	$1,339.50

Causes, Number, and Duration of Delays from Electrical Troubles by Months, from September 1, 1924, to August 31, 1925.

Cause of Delays	September		October		November		December		January		March		April		May		June		July		August	
	No.*	Time*	No.	Time	No.	Time	No.	Time	No.	Time	No.	Time	No.	Time	No.	Time	No.	Time	No.	Time	No.	Time
Motor burned out	5	43:00	3	22:35	2	26:00	1	4:50	2	15:30	2	14:30	2	19:55	4	25:30	3	24:00	2	16:00	1	17:00
Rotor troubles									1	5:00	1	10:00	1	20	1	35	2	35	2	55		
Burned motor terminals	1	45	4	4:10					1	40	1	35										
Change bearings	8	5:55	9	16:15	1	25	6	11:55	9	7:15	16	20:05	7	8:00	4	2:30	3	3:05	7	12:30	7	11:10
Oil rings	1	3:00	2	6:00					1	45												
End caps on ball bearings	3	13:45																				
Other motor troubles	1	30	4	3:00	3	3:05	1	15	3	1:10	2	35	3	1:30	1	20					1	10
Line troubles			1	10	1	20							1	15	1	1:30						
Compensator coils					1	45									1	1:30						
Compensator leads	4	10:15	1	2:00	2	6:00	2	2:50	2	2:00	1	1:00							2	1:45	2	2:25
Compensator relay coils					2	1:00					1	30	1	15	1	30						
Compensator contacts	4	1:40	14	8:15	9	7:30	3	1:10	4	1:15	1	30	2	35	3	1:25	2	40	1	15	1	15
Low voltage release coils	2	3:00	2	45							1	30	1	1:20			2	4:30	2	1:50		
Relay mechanism	4	4:55	3	1:05	2	1:55	2	1:05	7	2:25	2	30	3	55	9	3:25	7	4:25	5	3:05	1	2:55
Release push buttons					1	20							2	35								
Other compensator troubles	1	10					1	30	2	25	1	20	1	25								
Burned switch blades																						
Burned switch terminals					1	1:25			1	40												
Hummer vibrator coils	3	45	4	1:40	3	1:15			4	2:15	2	50	3	1:55	2	45	4	1:05			2	45
Hummer coil circuits			4	1:30	2	40	4	1:30	1	25			1	10			1	1:20			1	15
Other hummer troubles			1	25	3	1:05			3	1:25					1	1:20	3	1:25	1	1:30		
Hummer generator troubles			11	11:15	1	05	1	20	1	45	2	20			4	1:50	5	3:10	6	3:55	2	1:00
Fuses	14	3:05	5	1:40	1	15	5	2:10	2	50	2	20	6	2:50	2	30	1	10	4	50	1	15
Total	51	90:45	68	80:45	35	52:05	26	26:35	44	42:45	35	50:35	34	39:00	34	41:40	33	44:25	32	42:35	19	36:10

Plant shut down for repairs during month of February, 1925.

*Vertical colums represent number of delays for the month and their duration in hours and minutes.



The preparation and field erection costs were lowered more than 40 per cent by the use of arc welding instead of riveting for the structural work of this building.

It will be noted that the saving in favor of the arc-welded building lies in the minimum of preparation required—merely the cutting of the steel to the required length. No clip angles, gusset plates or butt straps are necessary, while besides these, the riveted job involved shop details and layout, punching, painting, reaming and shop fabrication. In the riveted structure 27,100 lb. of steel were used, while but 25,619 lb. were used in the welded structure—a reduction of 5½ per cent in favor of the welded type of construction. The saving in steel and reduction in total erection cost in this case resulted in a final saving of 41.3 per cent in favor of arc welding.

While there have been numerous applications of arc welding in the fabrication of structural steel, test data involving welded joints have not been complete. Tests were, therefore, made of welded joints for tensile, shear, static, shock and fatigue strength of such joints, compared to similar joints made by riveting, and to the steel members welded together.

Using ½-in. and ⅜-in. plates beveled at 60 deg. and arc welded to form a butt joint as a section subjected to tensile strength tests, it was found that the joint in the ½-in. plate developed an average tensile strength of 64,400 lb. per sq. in., with an elongation of 4 per cent in a 1-in. section across the weld. The steel in which the joint was made had a tensile strength of between 65,000 and 70,000 lb. per sq. in., and failure in the piece occurred in both base and deposited metal. Welding wire used was hard-drawn, mild steel, having a carbon content of 0.17 per cent and a manganese content of 0.55 per cent.

In the shear test, a similar joint developed 50,550 lb. per sq. in., and when subjected to static tests, a pressure of 40 tons deformed the supporting beams completely, but failed to produce any evidence of failure in the welded joints. In fatigue tests, a riveted and a welded joint of similar design were mounted on a vibratory testing machine and subjected to a vibration or vertical movement of 1/16 in. at the rate of 1,760 complete cycles per minute. After 18 hr. and 20 min. there was hardly a joint in the riveted member which was not thoroughly loosened, the rivets worn, the rivet holes enlarged, and a number of portions broken off the main section. When finally the welded model failed after a long and more severe test, failure occurred in the beams and not in the welded joints. Under a sudden shock of 700 tons administered directly to an arc-welded joint section, the welds did not fail, even though the structural steel members of the section were severely strained and deformed.

The cost of arc welding, in practically all cases, is considerably lower than riveting or other processes. A ⅜-in. fillet weld can be put in for between 15 and 20 cents per linear foot of bead, depending somewhat upon the position of the work. This estimate is based upon labor at $1 an hr., welding wire at 10 cents per lb., and electrical energy at 2 cents per kw-hr.

A. G. BISSELL.
General Engineering Department,
Westinghouse Electric & Mfg. Co.,
East Pittsburgh, Pa.

Maintenance of 4,000 Motors

(Continued from page 56)

However, it is noticed that considerably poorer power factor results. For instance, the power factor of the stamping plant is 50 per cent, as compared with the plant average power factor of 75 per cent.

With the exception of the cranes and industrial trucks and tractors, automatic or push button control is used throughout the plant. Here too, the equipment used has been standardized as much as has been possible.

For example, control for squirrel-cage motors is standardized as follows: For motors of 7½ hp. or less, push-button-operated, across-the-line starters are used exclusively; for squirrel-cage motors between 7½-hp. and 30-hp. rating, primary-resistance starters are used exclusively; for squirrel-cage motors larger than 30 hp., only push-button-controlled, automatic compensators are used as control equipment.

For transforming 2,300 volts to 440 volts for power purposes, a standard arrangement of three 300-kva. single-phase transformers, connected delta-delta, is standard in all of the plant substations. Likewise, a 50-kva. single-phase transformer is standard for transforming from 2,300 to 110 volts for lighting.

The same idea of standardization is carried out throughout all of the electrical equipment, wherever it is at all practical. Due to the fact that the Chief Electrician decides upon and specifies what type and make of equipment shall be purchased, standardizing on sizes and types is comparatively easy. The Chief Electrician specifies not only what type and make of motor and control shall be purchased but also he specifies the same for all other electrical equipment including electric portable tools, electric industrial trucks and tractors, travelling cranes, electric hoists, and the like.

Standard schemes of installation are used wherever possible. For example, the lighting distribution boards are made up of a standard arrangement of safety switches mounted on an iron framework. Likewise, the starters for squirrel-cage induction motors are made up in standard forms that include a starter and safety switch arranged on a pipe frame mounting.

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

G. A. VAN BRUNT, *Managing Editor*

Compare Your Methods and Equipment With Those Used in Other Plants

ORGANIZATION schemes and methods of handling work must have a certain amount of flexibility in order to properly meet emergency conditions that arise from time to time. In addition, both organization set-ups and methods require revamping once in a while to adapt them to changed conditions. This is especially true of the maintenance organization of a growing industrial plant. Additions to or changes in equipment and product or processes may so alter conditions that methods and schedules which were entirely adequate when first put into effect are now of comparatively little value.

A good way to judge methods and results is to compare them with those of other men engaged in similar work. Even though operating conditions in different plants vary considerably, it is usually possible to find a basis on which fair comparisons of both methods and results can be made.

This issue of INDUSTRIAL ENGINEER affords a good opportunity to learn the details of the equipment and methods used by the operating and maintenance executives in a large number of industrial plants, and the results that they are obtaining. Careful study of what they have to say may give you reason to feel well satisfied with the manner in which you are handling your work. On the other hand, it may show you where changes in your testing and repair equipment or methods may be made to good advantage. In any event, the time will be well spent.

How Much Trouble Do Rule-of-Thumb Methods Cause You?

IN MANY cases the "rule-of-thumb" and "cut-and-try" methods sometimes used in maintenance and repair work are the underlying cause of many troubles with mechanical equipment. This is sometimes seen in such operations as machining sleeve bearings or in babbitting a worn bearing.

The methods used by the engineer in solving problems arising in the design of machinery, were compared with those used by men who substitute guesswork for analysis, and chance for judgment, in a paper recently presented before the American Institute of Mechanical Engineers by Forrest E. Cardullo, Chief Engineer of the G. A. Gray Co.

In discussing this subject, Mr. Cardullo spoke of the false impressions and large amount of misinformation that exists regarding the design and use of bearings. In his opinion, the best bearing, where possible to apply it, is a perfectly cylindrical sleeve, the hole through the sleeve being larger than the shaft by an amount sufficient to permit an oil film of proper thickness. Such a bearing is quite different from one produced by the very common practice of making a hole the same size as the shaft and then "scraping in" or "fitting" the bearing. A bearing that has been "scraped in," he said, has no room between the shaft and the box for an oil film.

Half-boxes were said to be required in some cases in order to assemble the bearing, but in such instances two half-boxes should be machined to a perfectly cylindrical hole and no shims used. The use of a quarter-box was characterized as a crime and it was stated that a great deal of bearing trouble could be eliminated by the substitution of a properly designed half-box.

In speaking of lubrication and oil grooving, Mr. Cardullo stated that the figure 8's, criss-crosses, and complicated systems of reversed spirals with which many bearings are provided, show that the men who designed them are ignorant on these points.

The improper practices referred to were developed by rule-of-thumb procedure and guesswork. Analysis and application of the correct principles have resulted in important improvements in bearing design. The chances are that the same measures applied to all of your maintenance and repair operations will produce equally fruitful results.

Do You Give the Maintenance Department Full Credit for What It Does?

ONLY too frequently is there a feeling in industrial plants that the maintenance department is a non-producing department. It is so-called because its output does not show up directly among the finished products sold by the plant. This being the case, there is a tendency in some organizations to neglect this department or consider it second when distributing bonuses, salary increases, working equipment, and the like.

This policy is not sound, for the maintenance of the plant is fully as important as any phase of production. Henry Ford says very forcefully, "The first duty of management is to keep the tools in shape. By the tools is meant the entire plant and everything pertaining to it." To go a little further, the main function of the maintenance department is to see that the capital invested in producing facilities is conserved and pays the highest possible rate of interest. This means the equipment must be at all times in condition to produce at full capacity. In the face of this can anyone say that production is more important than maintenance? They are on a par and should be so considered. The output of the maintenance department is a service that is vitally essential to the quantity as well as the quality of production.

Due to the more far-sighted policy of some plant managers and also to the aggressiveness of many maintenance superintendents, this fact is fast becoming recognized in our more progressive plants.

Let the Repair Shop Help to Cut Your Maintenance Costs

MUCH stress has been placed, and rightly so, on the importance of securing the most effective layout of production equipment and eliminating as completely as possible all waste motion and effort on the part of the workman. However, in this effort to obtain maximum output for the time and effort expended, the plant repair shop is often overlooked. In consequence, the arrangement of equipment in many shops has been left to chance and circumstance. Oftentimes, too, facilities are lacking for handling the work in the most efficient manner.

In volume of output and number of employees, the plant repair shop may not rank very high when compared to some of the production departments, but that is no reason why time-saving methods and equipment can not be employed just as effectively there as in any other department. If the use of good equipment and efficient methods make it possible to shorten by a few hours the time required to repair an important motor or other piece of equipment, the saving in production delays on one or two such jobs may go far toward paying the cost of putting the shop on an efficient basis.

A little time spent in studying the equipment, its layout, and the general method of handling the work in your repair shop may show where some worth-while economies that will help to cut maintenance costs, can be easily effected.

Good Equipment Is Worth the Care That It Should Have

SOME industrial operating men, who have adopted the policy of purchasing only standard-quality equipment and supplies, have looked merely at one side of the problem confronting them. They have paid more, generally, to get quality and naturally expect better service from it, but the equipment is not always installed and operated in such manner as to secure this extra measure of service.

There is more to be considered than merely buying the "best on the market." Suitability for the work in hand and care during and after the equipment is installed are just as important. Even the highest-priced automobile will freeze up during winter weather unless some anti-freezing mixture is used in the radiator, or be ruined unless oiled regularly. Also, the best machine or other equipment will have a short life unless it is oiled, cleaned, and cared for regularly.

"Buy the best and forget about it" is a good policy to adopt, providing it is not followed too literally.

Poor Yard Roads Cost as Much as Good Ones

IN MANY lines of industry it is necessary to use yard storage, for example, for the seasoning of castings or lumber, or for storage of flasks, coal, and other materials. In bad weather and particularly during the winter and spring it is often almost impossible to move these materials from storage unless the yard is provided with a roadway which is passable to trucks.

Operating men who will stop to figure out the cost of the waste time and extra men required to help extricate trucks that are stuck in a so-called road, will not find it difficult to convince themselves that a substantial concrete or macadam roadway, or even one made of cinders, if it is kept in shape with a little attention, will much more than pay for itself.

Electric storage battery trucks and cranes, which are commonly used for yard haulage, are capable of carrying considerable overload. However, the task of pulling themselves out of the mud and carrying a load at the same time is certain to be reflected in increased maintenance costs as well as shorter life of the equipment. These items should not be overlooked when determining what poor yard roads cost.

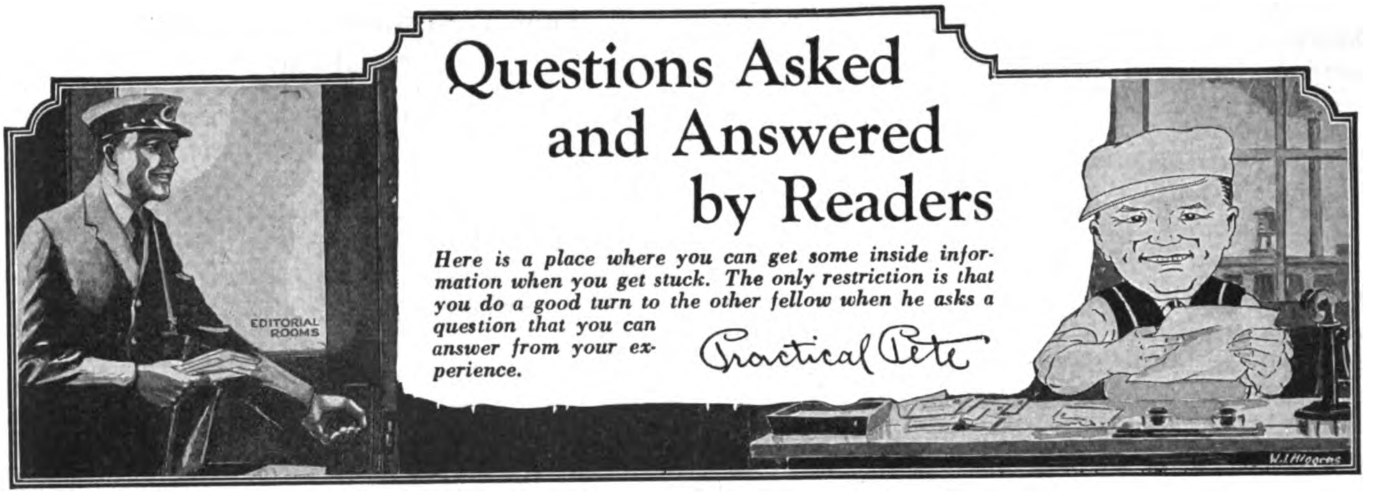
Can You Perform the Prone Pressure Method of Resuscitation?

A FOOLISH question, you may say. Yet is it? We have seen long descriptions and illustrations of how to do it placed in many sub-stations and other places where someone is likely to be hurt by electric shock. Yet when the time came, there was no one that knew just what to do.

The prone pressure method is extremely easy to learn, but is hard to describe. At a recent meeting of an association of practical electrical engineers the method was demonstrated, and although these men are in direct charge of many electrical workmen and it would naturally be assumed that they know all about the method, the amount of interest displayed was astonishing. Many of these men went home with the thought that this life-saving method should actually be demonstrated to all of their men, rather than put on notices scattered around the plant. Then when the emergency comes, someone will know exactly what to do, and how to do it.

In many instances this method has saved the life of persons who were considered to be beyond help. So, no matter what may be the condition of the victim, the method should be applied and kept up for some time.

The prone pressure method is adapted for use in cases of electric shock, asphyxiation by gas, smoke or other fumes, and drowning, and is preferred to other methods, by some authorities. Practical and frequent demonstration by and to your men may be the means of saving many lives. Do it today.



Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Practical Pete

Who Can Answer These?

Selecting High-Pressure Bearings.—In one of our manufacturing processes the product is rolled under high pressure. We have always had considerable difficulty with the bearings and as we are going to rebuild the machines are considering installing other types of bearings. I would like to know what types of bearings other operating men favor for paper calendars, rubber mills, and cereal rolls, as I believe our problem is similar. Will some readers from these industries please give me their experience with babbitt (including the type), bronze bushings, ball or roller bearings and the method of lubrication which they have found most satisfactory?
Brooklyn, N. Y. J. A. A.

* * * *

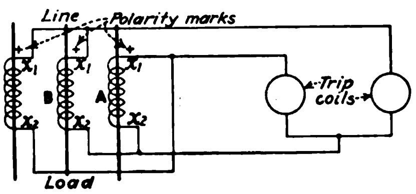
How Much Insulation Should be Put on Cable Splices?—Can some reader tell me how many layers of varnished cambric tape should be used for insulating the splices of lead-sheath power cables of the following voltages: 110, 220, 440, 550, 4,000 and 20,000 volts. Do you think some other kind of tape preferable for this work? I shall be grateful for any information that readers can give me regarding the amount of insulation that should be used when splicing cables of the above voltages, and also for any other information or suggestions as to the best method of handling it.
Toledo, Ohio. S. J. M.

* * * *

Is Hard-Drawn or Cast Copper the Better Material for Commutators?—I would like to find out the difference in operating characteristics, if any, between commutators made from hard-drawn copper and from cast copper. In the advertising literature of many of the large manufacturers of motors and generators, commutators are frequently described as being made of hard-drawn copper. Some repair shops furnish commutators made from cast copper. Which material wears the longer? Which material will polish better under the brushes? Does the sand in the cast copper cause eating away of the mica segments between the bars? Would the use of cast copper segments cause excessive heating of a generator or motor? I shall appreciate any information or comments that readers can give me regarding their experience with either type of material.
Cleveland Heights, Ohio. C. B. K.

* * * *

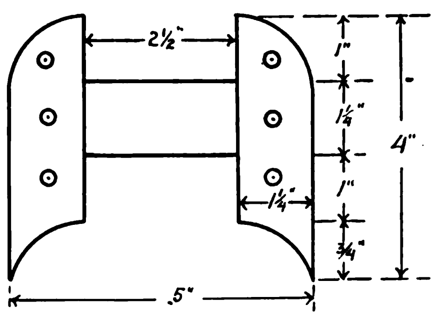
Is This Relay Connection Scheme Correct?—I have a 300-hp., three-phase, 60-cycle induction motor that is star-connected to a 4,000-volt, four-wire, three-phase, power supply. Three 75-to-5 ratio current transformers are connected as shown in the diagram to the two trip coils on the circuit breaker for this motor. I believe this connection scheme is incorrect. It looks like a delta connection, but has one current transformer reversed. I think that a "Z" connection of current transformers should be used, but that is not the case here. Will some reader show me how these current transformers should be connected to



insure proper protection of the motor, and also tell me the proper current setting of the trip-coil plunger, so as to trip at 125 per cent load on the motor? Full-load rating of the motor is 39 amp. The trip coils referred to are solenoids located on the faceplate of the circuit breaker and have plungers operating directly on its trip latch.
Waukegan, Ill. S. D. H.

* * * *

Winding Data for Growler.—I wish to build a growler of the dimensions shown in the accompanying diagram, for use in testing armatures in our shop. It is my intention to wind this growler with No. 12 double-cotton-covered magnet wire and I wish some reader would tell me the number of turns of wire to use and also the depth of laminations required. I want to use this growler on 110-volt alter-



nating current. Any information that readers can give me about making up this growler will be greatly appreciated.
Hattiesburg, Miss. J. M. M.

* * * *

Determining Number of Poles in Stator by Use of Compass.—(1) Can some reader give me a simple method of determining the number of poles in two- and three-phase stators when the nameplate is missing? That is, can I pass direct current from dry cells or other source through the winding and use a compass to locate the poles? Or will it be necessary to trace out the winding? How should I go about tracing out a winding to find the number of poles? (2) Why does the terminal on the positive pole of a storage battery corrode, while the negative terminal does not? I shall appreciate your help on these questions.
Worcester, Mass. R. S. T.

* * * *

Paralleling Open-Delta-Connected Transformer Bank With Closed-Delta Bank.—I would like to obtain the experience of some of our readers in regard to parallel operation of an open-delta-connected bank of transformers with one or more closed-delta-connected banks of transformers. Under what conditions is such operation possible? How does the load divide between the several banks of transformers? How is the capacity affected of both the open-delta bank as well as the closed-delta bank? If we have two banks of closed-delta-connected transformers operating in parallel on both the high- and low-tension sides, will these two banks of transformers continue to operate satisfactorily and divide their load in accordance with their capacity, if one transformer is cut out of one bank so as to make an open delta connection? In this particular case, all of the transformers are of the same size, voltage, ratio, reactance, and were made by the same manufacturer.
Wilmington, Del. H. E. H.

* * * *

Answers Received To Questions Asked

Ramp for Industrial Truck.—The basement floor of one of our buildings is 4 ft. below the grade level. We are planning on installing an electric storage battery truck for handling heavy material out of this basement and from the yard up to the first floor. What grade should be given to the incline or ramp? Would it be advisable to roughen or ridge the surface of the concrete to give the truck better footing? Part of the ramp will be outside, and exposed to the weather.
Peoria, Ill. S. L. G.

In reply to S. L. G.'s inquiry, he will find that the longer and more gradual he can make the ramp the easier it will be on the battery and the truck. Standard makes of trucks can be equipped with batteries large enough to handle any reasonable load on any reasonable grade. My experience has been that even where a truck is equipped with a battery somewhat larger than standard rating, a grade of 1 in 8 is about the operating limit. The truck labors on this grade with its rated load unless the battery is fresh from charging.

I do not know what figure truck manufacturers use in estimating tractive effort on level floors, but after taking into consideration the heavy going due to unavoidable irregularities

a value of 20 per cent of the load, which is often used in similar work, would probably be a fair upper value. Thus a grade of 12.5 per cent on top of the regular tractive effort would increase the effort required of the motor 62.5 per cent above that for hauling on the level. I would suggest that S. L. G. make his ramp 50 ft. long, if possible, which would give a grade of 1 in 12½ or 8 per cent, as it will be much easier on the truck batteries.

For the usual rubber-tired truck wheels, a plain concrete surface, finished with a wooden float but not troweled, will give ample tractive contact, even if wet, and is much better than any form of ridges or grooves, which only bump and impede the truck. It is a good idea on a runway such as this to use an integral floor hardener, such as some of the powdered-iron preparations, as they greatly reduce the wear of the surface.

In building a ramp the grade should not start and finish abruptly, but should gradually curve from the level floor to the full slope or incline of the ramp.

This transition at the top and bottom may well be 6 to 8 ft. This is especially important if the grade is steep, because where the transition is short and the truck under-clearance small it may rub or become stranded when going over the top. Also the truck would tend to bump at the bottom of a sharp transition. Steering rods are usually the lowest part under the frame and should be inspected occasionally to see whether they are scraping as otherwise they may break and cause a bad wreck. H. D. FISHER.

Plant Engineer,
New Haven Pulp & Board Co.,
New Haven, Conn.

* * * *

Will Two A.C. Motors Operate Satisfactorily in Parallel?—We have a turntable driven by a variable-speed, slip-ring a.c. motor. This motor is too small and rather than incur the expense of buying one motor that is large enough to handle this job, we are considering buying another motor, a duplicate of the present one, and connecting it directly to the table, so that the two motors will both drive the table in parallel. Will the motors operate satisfactorily in parallel? Can we operate both motors from the same secondary resistance and controller, or should we use two drum controllers and two independent resistances? I will greatly appreciate any information and experiences that other readers can give me on this subject.
Omaha, Neb. G. C. B.

In reply to the question asked by G. C. B., we have two, three-phase, slip-ring, Allis-Chalmers motors, one rated at 400 hp. and the other at 200 hp., running in parallel on a copper rod mill drive. These two motors are direct-connected to opposite ends of the same shaft.

These motors are both fed from the same oil switch; one trip coil with current transformer being used for overload protection for the 400-hp. motor and the other trip coil for the 200-hp. motor.

Each of the motors also has a double-pole, push-button-operated, magnetic contactor. Red indicating lamps are installed on the panel with the push buttons, informing the operator when the contactor for either motor is closed.

The machine is normally started without load and can be started only by means of the 400-hp. motor; this motor has a secondary controller and resistance of the usual type. We have added an interlocking contact at the bottom of the controller which makes contact on the last point and is connected in the push-button circuit to the contactor coil of the smaller or 200-hp. motor.

Hence, only when the drive is up to speed, can the second motor be started. This is accomplished simply by pushing its start button. The rings of this motor are permanently short-circuited by means of German silver strips connected across the brush holders. The purpose of these strips is to insert a low resistance in the secondary of this motor, and the length of the strips was adjusted by trial until the motor was carrying its proportionate share of the load. In case the load is light either motor may be tripped off the line and the load carried by the other.

In the case of the turntable mentioned, since the motors are variable speed and both will be required at starting, I believe the simplest method would be to provide a separate secondary resistance and controller for each motor, gearing the controllers together so that they will operate together as a unit.

It would be possible to parallel the motor secondaries and use one resistance if the rotors have the same voltage characteristics and are phased out properly when connected. In this case a resistor of greater carrying capacity would be required. However, the present controller might serve, if of generous design.

The second motor will not need to be as large as the original motor unless twice the horsepower of the first motor is required. W. W. LANKTON.

Ass't. Electrical Engineer,
Detroit Copper & Brass Rolling Mills,
Detroit, Mich.

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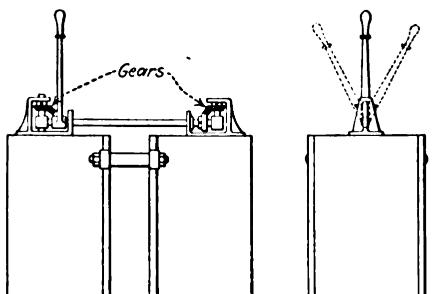
Replying to G. C. B.'s inquiry, it is possible and practicable to operate two motors in parallel to drive the turntable.

The second motor should be an exact duplicate of the first motor in full-load speed and secondary characteristics. The drive pinion on both motor shafts should have the same number of teeth and pitch.



Method of mechanically connecting two controllers for wound rotor motors driving same shaft so as to start them simultaneously.

One drum and a separate secondary resistor are required for each motor The drums should be mechanically interlocked by means of a duplex drive arranged as shown in the accompanying diagram. The drums should be of the same design and the secondary resistors laid out for the same load and speed reduction. Drums designed to operate motors in parallel are built by manufacturers of electric controlling devices. E. H. LAABS.

Engineering Department,
The Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

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Regarding the question asked by G. C. B. two slip-ring motors can be made to operate satisfactorily when connected to the same load. To carry out the scheme successfully, the rotors should have independent rheostats with a single control lever. As this lever is moved, it must cut in or cut out resistance to the same amount in the rotor of each circuit. Motors in this case must have the same electrical characteristics. The primary or stator windings are connected in parallel and are switched or reversed by a single switching mechanism.

There are installations where two slip-ring motors controlled as described above, are in use on railroad turntables that are successfully giving the desired balanced drive. Should G. C. B. so desire, we could probably arrange to have him correspond directly with the men who have charge of installations such as those that have just been mentioned so as to obtain further information.

Allen-Bradley Co., W. S. PFEIFER.
Asst. Chief Engineer,
Milwaukee, Wis.

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In reply to G. C. B. I would say that theoretically it is poor practice to operate two slip-ring induction motors in parallel; that is, with their secondaries using the same secondary resistance. There probably will always be some circulating currents between the two machines.

Two-motor controllers that are designed for such work as this, have a double-cylinder development which keeps the resistors of the two machines entirely separate. On the first point of such a controller the two motors are simultaneously thrown across the line with resistance in the secondary circuit. On succeeding points of the controller, blocks of resistance are simultaneously cut out of the secondary.

It is the writer's personal opinion that fairly satisfactory results can be obtained using duplicate motors in parallel on a single motor controller and having the same speed, horsepower, etc., and, of course, built by the same manufacturer, particularly if the service is intermittent as is the case with motors driving a turn-table.

Before deciding on using two motors operating in parallel it would be advantageous to compare the cost of the additional smaller motor with the cost of a motor large enough to carry the entire load. The additional cost of the

larger motor will, of course, be offset somewhat by whatever could be secured from the sale of the motor that it replaces. G. C. B. does not state the size of the motor he has nor how much more power is required. If a 20-hp. motor is now used and a second motor is required it must also be rated 20 hp., for successful parallel operation on a single motor controller. If a 20-hp. motor is able to handle the load at present I doubt whether a 40-hp. motor is needed; possibly a 30-hp. motor would be large enough. An investigation of the difference in price between a 20-hp. motor and a 30-hp. motor will probably show that the increased cost of the larger motor will not be so great as expected. The chances are that the controller now in use will be large enough to handle the larger motor.

The starting resistor will doubtless have to be replaced and if so, care should be taken that the grids have ample mechanical strength to withstand any breakage caused by the jar of the locomotive when it comes onto the turntable. Also, using one motor instead of two will reduce the upkeep and make a better job in every way.

R. F. EMERSON.

Industrial Engineering Dept.,
General Electric Co.,
Schenectady, N. Y.

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In answer to G. C. B.'s question, I would say that two wound-rotor induction motors may be operated in parallel.

If the motors are permanently connected together mechanically a single primary and a single secondary controller may be used for starting both motors.

In making the permanent mechanical connection between the two rotors care should be taken to phase out the rotors to insure proper phase relations.

Hopewell, Va. R. M. BUSH.

* * * *

With reference to G. C. B.'s question, I believe that it will be satisfactory to operate the two slip-ring motors in parallel if the new motor is a duplicate of the present motor. It will be necessary, however, to have an independent drum controller and secondary resistance for each motor as they cannot be operated satisfactorily with a single drum controller and resistance. If the two drum controllers are mounted side by side and operated simultaneously, no difficulty should be experienced in their operation, but it will be necessary to make frequent inspections to be certain that the primary fuses of each motor circuit are intact. It would be better of course, on account of the added complications, to use a single motor of the proper rating.

East Cleveland, Ohio. L. J. JOHNSON.

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Answering G. C. B.'s question as to operating two slip-ring motors in parallel, I would say that this can be done successfully by using one secondary resistance and controller twice the size of the one now in use. Two separate controllers and resistances could be used but would have to be moved together or one motor would take more than its share of the load. Therefore, one control would be far better. The motors should be of the same make and type, as some motors take more current on starting and also have more torque.

The writer has worked this out a number of times on machines requiring two motors, especially flour milling machinery. Of course, the rotors of the two motors must be properly phased out before the rotors are connected in parallel.

Williamsport, Pa. R. M. KONKLE.

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In answer to G. C. B., on operating two alternating-current motors in parallel, I assume that he has in mind two polyphase, variable-speed, induction motors.

It is practicable to have two motors coupled to a single load. Both motors must be started together. One way to do this is to excite the stators, then with two separate drum controllers and resistances start the motors. The shafts or handles of each controller should be coupled together in a manner similar to a double controller. Hence both motors are started together, if both resistances are alike. In this manner both motors have the same acceleration and each motor will carry one-half of the total load.

San Francisco, Calif. P. P. SCRIBANTE.

* * * *

In reply to G. C. B., I have had unusually good success in operating two slip-ring induction motors, connected in parallel, from the same controller and resistance, the motors being the same size, make, etc. We made tests to ascertain the characteristics of each motor. After it was found that the motors were almost identical in every way, they were connected together by means of a flexible coupling, the controller and resistance being approximately doubled in capacity for this duty.

Although this arrangement was satisfactory, I would recommend that a motor, having the necessary capacity, be purchased as it will give better efficiency.

PHIL D. COMER.

San Bernardino, Calif.

* * * *

Method of Drilling Holes Through Plate Glass.—I have to drill some holes in plate glass ¼ in. thick and wish some of our readers would tell me the best way of doing this. I have tried various methods but without much success and shall appreciate your suggestions.
Little Rock, Ark. M. J. J.

In answer to M. J. J., I have used the following method for drilling holes in glass with very good results.

The necessary tools are a small drill press, a piece of copper tubing with an outside diameter equal to the size of the hole to be bored, a quantity of powdered carborundum and a little turpentine. A block of wood about 1 in. thick with a hole bored through it the size of the tubing, should be used as a guide for drilling.

The copper tubing must be firmly held on the spindle of the drill press. In order to do this, heat one end of the tubing and drive it over the spindle while hot. The tubing should revolve at 50 or 60 r.p.m. and the carborundum moistened with turpentine should be fed into a hole cut in the side of the tubing. The pressure must be slight, and the tube should be raised frequently to allow fresh cutting power to work beneath it.

In cutting plate glass by this method, it will be necessary to grind off the cutting end of the tubing once or twice, in order to obtain the full thickness of the wall. With this method about an hour is required to cut through $\frac{3}{16}$-in. plate glass.

Oakland, Cal. ROBERT BUCKETT.

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Referring to the question by M. J. J., gum or glass camphor will make the process of drilling glass almost as simple as drilling hard wood.

Glass camphor may be obtained at almost any hardware or paint store. An ordinary drill bit, such as is used for drilling metal, may be employed and the glass camphor should be applied in small drops at the point of drilling. Care must be taken not to apply too much pressure while drilling, especially when the hole is nearly through. PHIL D. COMER.

San Bernardino, Calif.

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Referring to the inquiry by M. J. J. about drilling holes in plate glass, a brass tube made be used with good results for boring large holes. The brass tube should be held in a drill press chuck and guided through a hole in a cork cemented to the glass being fed with powdered emery, and water should be applied to the lower end of the tube.

For drilling smaller holes a flat drill, similarly centered and lubricated with either turpentine or an alcoholic solution of camphor will work satisfactorily. This drill should be at least of file hardness to give good results.

Most glass can be filed the same as cast iron if the file is moistened sufficiently with one of the above solutions. H. D. FISHER.

Plant Engineer,
New Haven Pulp & Board Co.,
New Haven, Conn.

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In answering M. J. J.'s question I will assume that he has unlimited patience; otherwise there is but one answer, and that is to have someone else drill the glass for him.

An ordinary drill can also be used if it is dipped in muriatic acid of medium strength to keep it in glass-cutting condition. Quite naturally, this means the end of that drill's usefulness.

Turpentine applied to the glass is very beneficial regardless of the means of cutting, and when carborundum is mixed with turpentine and applied to the glass a simple drill can be used.

This drill can be made by breaking off the point of a three-cornered file to a 2½-in. or 3-in. length. It should be used in a hand drill at a good rate of speed and not much pressure.

Extreme care must be taken when the hole is nearly through, for the

glass is then quite weak and it is at this point that breaking usually occurs, if too much pressure is applied, or by allowing the drill excessive freedom. Naturally, the glass must be securely fastened to a base while it is being drilled. Do not economize on turpentine, use a fair speed and decrease the pressure as the drilling progresses. These precautions together with a whole lot of patience, will insure satisfactory results.

Newark, N. J. EDWARD JAMES.

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In answer to M. J. J., any hard steel tool will cut glass fairly easily when moistened with camphor dissolved in turpentine. To support the tool a drill bow or even the hand alone may be used. A round hole may be readily enlarged with a round file moistened with turpentine and camphor. Flat window glass can be sawed with an ordinary watch spring saw and even the most brittle glass can be worked without difficulty by the use of cutting tools kept constantly moist with the above solution. MARTIN G. LANE.

Electrical Engineer,
Climax Molybdenum Co.,
Climax, Col.

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Replying to M. J. J., I have found the following method to be very useful indeed.

A tool for this purpose is made from a mild steel rod of suitable length, with an outside diameter approximately 0.012 in. smaller than the actual size of the hole required. The cutting end is hollowed out with a drill, leaving a wall thickness of 1/16 in. The other end of the rod is held in a hand or breast drill.

A flat surface is required, such as a drawing table or desk table padded with newspapers. A piece of paper the size of the glass is marked out for the holes and the glass is laid over the paper.

A wooden block with a hole the size of the tool is placed on top of the glass and a weight, preferably one with a hole in it, is put on the wood to keep it from shifting out of place. Carborundum and turpentine are poured on the glass through the hole in the wood, and when the tool is placed in the hand drill and rotated on this abrasive, it will bore a clean hole in approximately 20 min.

If it is desired to have a smooth edge on both sides of the glass, just reverse the sides when the hole is bored halfway.

If the piece of paper with the locations of the holes is the exact size of the glass, it will help to locate them accurately when the glass is reversed. Carborundum and turpentine should be added from time to time as the glass is worn away. After the hole is started and is about 1/16 in. deep, the wood may be removed, which will make it easier to feed the tool with carborundum and turpentine.

If the glass is small and a drill press is available similar results may be obtained by running the tool at slow speed and feeding it lightly, but often, with carborundum and turpentine.

Montreal, Que., Can. J. C. BRAY.

Stopping Breakage of Gears.—On each battery of furnaces in our refinery there is a 7½-hp., 1,800-r.p.m., motor driving a device that clears the coke from the furnace. The motor is connected by a roller chain to a shaft driving a pinion meshing with a large double gear that drives the device. This device is subjected to very unusual loads at times, especially when it is about time for the furnace to be rebuilt. These loads are so heavy and come on so suddenly that the teeth are often broken off the bevel gear, which is made of cast iron. As it is rather expensive to replace these gears, I am wondering if our readers can suggest some device that I could put on this drive to disconnect it when the load becomes too great. Would a coupling having shear pins do the trick? How could I make such a coupling?

Tulsa, Okla. L. A. N.

In reply to L. A. N., a motor speed of 1,800 r.p.m. is, in my estimation, too high for the use of a roller chain. I would recommend the use of a silent chain, which is better adapted to regular motor drives. Also, I believe that a shearing pin sprocket could be used to good advantage in your case.

Ithaca, N. Y. A. B. WRAY.
Morse Chain Co.,

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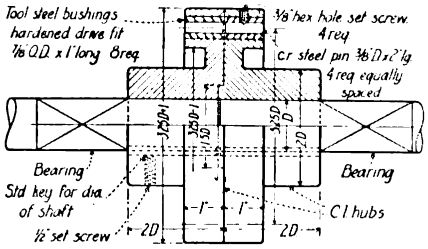
Answering L. A. N., if the suddenly applied heavy loads do not stall the motor, it would appear that the gears are not of the proper design. Cast-iron gears repeatedly subjected to sudden,



The dimensions of this shearing-pin hub are given in terms of the diameter of the shaft on which it will be mounted.

heavy loads will crystallize with the result that breakage occurs at normal or even light loads. I suggest making the bevel gears of steel castings.

A shearing-pin hub can be used to advantage in places where the machine elements are subjected to severe heavy loads.

In the absence of data regarding the speeds of the shafts, gear and chain ratios, diameter of shafts and so on, it is difficult to design the proper shearing pin device. However, the accompanying sketch gives the proportions in terms of the diameter of the shaft on which it is to be mounted. The tool steel bushings are not essential as far as the functioning of the device is concerned, but are of value when removing the sheared pins, as they protect the hole from being torn or wedged. The shearing pins are grooved in the middle to a reduced area depending upon the maximum torque required to operate the shearing device.

Since there is not sufficient information given to calculate the torque at the point where the shearing-hub device could be located the size of the groove can be obtained by trial or actual experience. The shearing-pin hub should be supported by a pillow block bearing at each side.

Engineering Dept., E. H. LAABS.
Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

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Why Does One Brush Arc on This Commutator?—I have been testing some series-wound motors rated at 1/60 hp. These run 1,600 r.p.m. under load and take about 0.4 amp. Speed is governed by a three-ball friction governor. With the governor released, the speed is 7,000 r.p.m., at no load. The motor is connected in series with 180 ohms resistance across a 110-volt a.c. line, thereby impressing about 38 volts across the armature.

We have considerable trouble with the brushes arcing and cutting the commutator. This makes the speed very irregular; so we are trying to improve the commutation. Offsetting the brushes so that they do not track increases the trouble. One brush will arc badly, while the other does not and leaves a very little carbon deposit on the commutator.

The commutator has 36 segments and is 1¼ in. in diameter. We have used several grades of brushes, but the best lasted only 368 hr. If anyone can explain this trouble or help me improve the commutation, I shall appreciate it.

Camden, N. J. L. G. J.

In answer to L. G. J., I believe that the chief cause of sparking in his case is an unbalanced armature, or it become unbalanced after the governor is attached or connected to the armature.

Another cause may be that the commutator is not running true with the bearings. If the commutator is the slightest fraction of an inch out of line with the shaft, it will cause sparking. To remedy this, turn the commutator in a lathe on centers. Be sure to clean the center, or recut the center in the armature, first.

Do not use a brush which is too soft; a good medium carbon brush will be necessary. The springs must have the proper tension.

The above suggestions are made on the assumption that the armature has been tested with a millivoltmeter for open circuits and short-circuits, and that the field is also free from shorts or grounds.

Los Angeles, Calif. H. A. NIELSEN.

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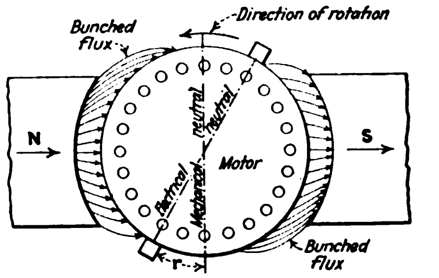
With reference to the question asked by L. G. J., I would say that series motors, which do not have a compensating winding, have the brushes shifted from the mechanical neutral against the direction of rotation, thus bringing them to the electrical neutral. To obtain this result the brushes are moved through the angle r, as shown in A of the accompanying illustration. Due to the armature reaction, the field flux will be stronger (bunched) on one tip of the pole than on the other, as shown.

If the direction of rotation is changed by either reversing the armature or field leads, the field flux will bunch on the other pole tip, thus changing the electrical neutral. Unless the brushes are shifted from the mechanical neutral in the opposite direction, as shown in diagram B, the brushes will not be on the electrical neutral. Therefore, sparking will be prevalent, but may be confined to only one brush.

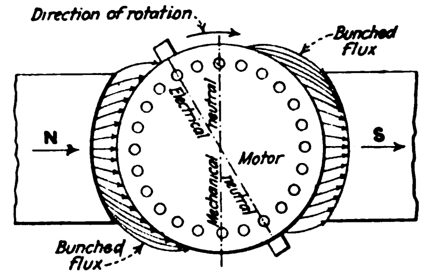
L. G. J.'s trouble may be due to the brush-holder and not to the internal connection of the motor, because the

This shows the relation between the electrical and mechanical neutrals for a series motor not having a compensating winding.

Diagram *A* shows the direction in which the brushes must be shifted for counter-clockwise rotation of the motor, while diagram *B* shows the relation for the opposite direction of rotation.



A



B

trouble is confined to one brush. Furthermore, the brush life that he is obtaining, is too short. This is an indication of low brush pressure causing the brush and the commutator face to burn away very rapidly. Rapid brush wear cannot be laid to too heavy brush pressure.

If the brush-holder is of the cartridge type, the coil spring should be carefully inspected. Sometimes it will catch on the inside of the brush-holder and will not apply sufficient pressure to the brush. Also, the spring may be too weak to apply the necessary pressure. In either case the spring tension should be carefully tested by lifting the brush from the commutator face.

Regardless of the type of brush-holder, it would be advisable to inspect the brush carefully to see that it works freely in the box and that the pressure on the brush is sufficient to give a good contact. Very often foreign matter will be found adhering to the inside of the box, thus preventing free travel of the brush.

From the data furnished I am assuming that the brushes are movable. Therefore, another suggestion may throw a little more light on the subject. Due to the fact that sparking is confined to one brush, and if the brush is found to work freely in the box with the proper brush pressure, the next step would be to check the brush spacing. If it is a two-pole motor, the brushes should span one-half of the commutator bars. The brush which does not spark is probably properly located in the commutating zone, while the brush which sparks may be shifted away from the commutating zone. Therefore, it would be short-circuiting bars that are connected to coils whose potential is not zero, thereby causing the brush to draw an arc when the bars pass out from under it. If this is the case, move the brush-holder holding the brush which does the sparking, in either direction until the sparking decreases.

The explanation of the increase in sparking with an increase in load is as follows:

(*A*) When the brush tension is low, or if the brush is sticking in the brush box, the increased current through a poor brush contact will increase the sparking. A simple test is to apply additional pressure to the brush. If the sparking stops, the cause is evident.

(*B*) If the brush is off the commutating zone, the increased armature current will cause an increase in the reactance voltage, which will in turn cause an increase in the short-circuited current which must be broken when the commutator bars pass from under the brush. J. M. ZIMMERMAN.

Renewal Parts Engineer,
Westinghouse Electric & Mfg. Co.,
Pittsburgh, Pa.

Method of Turning Commutators—I would like some pointers from readers as to the best way of turning commutators in a lathe. What size and shape of cutting tool should I use for the roughing cuts? Will this same tool be satisfactory for the finishing cuts? What is the best cutting speed? Would you recommend using sandpaper to give a final polish to the commutator or do you depend on the lathe tool to give the final polish? I shall appreciate any other details about turning commutators that readers can give me.
Hammond, Ind. H. H.

Answering the question asked by H. H., I use the same kind of tool as for turning shafting. Run the armature as near to operating speed as possible, taking light cuts until the commutator is true. Then sandpaper the commutator with No. 00 sandpaper, so that all tool marks are removed.

Grind a tool to a "V" point of the same thickness as the mica between segments. Now undercut the mica by moving the carriage with the pointed tool by hand and rotating the armature one segment at a time. After completing the undercutting, sandpaper the commutator again to remove all burrs. Finally blow out all traces of sand and copper cuttings. This treatment will give excellent results.

Chief Electrician, E. N. DILLARD.
Booth-Kelly Co.,
Springfield, Ore.

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H. H. will find that an undercut commutator should be turned at a fairly high peripheral speed, for a slow speed will cause the copper to drag over the slots.

In regard to the tool to use, I prefer a sharp, diamond-pointed tool, with one side (the side away from the cutting side) ground at an angle of 10 to 15 deg. This tool is used for the rough cuts. For the finish cut I prefer a slightly blunt nose on the cutting tool, but it should, nevertheless, be sharp.

By using a slightly blunt tool for the finish cut it will make a smooth cut even if the feed does not function in time with the revolutions of the armature.

After a good finishing cut, it should not be necessary to use a file, but as some mica and some copper is harder than others it may at times be necessary to use a file and also sandpaper. When using these, back up on the tailstock so as to let the armature turn very freely. Run the armature at a very high speed and use the file sparingly as a file or sandpaper will wear away the copper more rapidly than the mica, which will result in high mica unless the commutator is undercut.

It is also essential that the point of the tool be as high or even a trifle higher than the center of the commutator, for with this adjustment it will cut better, and you do not run chances of digging into the commutator. You can always tell if the tool is cutting properly by the shape of the chips. If they curl up and look smooth you can be quite satisfied that the commutator will have a nice finish. If the speed of turning is too slow, I find that the mica will not cut even with the copper, as may be determined by running your finger nail over the commutator.

In regard to the size of tool to use, I find that it makes very little difference as long as it is ground to the right taper. I may add that the tool should have a slight taper on top away from the cutting side, so that the chips will drop off about ¼ in. from the commutator. Only the top or cutting edge will touch the commutator.

NICHOLAS J. WEISS.
West New York, N. Y.

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The selection of a commutator turning tool is of less importance than many other item affecting this line of work, as the choice in most cases depends upon the machinist doing the work for most machinists have their favorite tools for different lines of work irrespective of best practice. The most important part is in setting the tool for a minimum cut with respect to the high points, which are surprisingly high in many cases.

Before any cutting is done it is a pretty good idea to protect the risers and the inside of the armature from the resulting dust and chips. About the simplest manner in which this can be accomplished is to tie a piece of cloth about the commutator as close to the risers as is possible, after which it should be stretched over the top of the coils and tied again, being tightened further after it has been tied in place on top of the coils.

Outside of care in the use of the tool and the taking of medium cuts, there is little to be said regarding the actual turning of the job. With manufacturers this generally resolves itself into two distinct processes, a rough cut followed by certain manufacturing operations and then by the finishing cut.

As to speed I have found that in turning a commutator without removing it from the generator a speed of 100 r.p.m. is satisfactory. In grinding a commutator, however, it is necessary to run it at normal speed with the grinding wheel running in the opposite direction. If the commutator on an

adjustable-speed motor is being ground, always grind it at its highest rated speed.

As to the polish I will say that I have seen a number of jobs turned out by using a roughing cut followed by sandpaper for polishing but it is the practice of a large manufacturer who is building up an enviable reputation to take two different cuts, slot the commutator and polish while running at the highest rated speed of the armature. This procedure gives an armature as nearly perfect as it can be produced.

However, for ordinary repair work a diamond-pointed tool with No. 00 sandpaper, used with consideration will produce very satisfactory results.

Newark, N. J. EDWARD JAMES.

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In reply to the question asked by H. H., I would say that we have found that any experienced machinist in our shop does very satisfactory work at turning a commutator. As to the speed of the lathe would say that this is not an important feature of the operation, but using a good arbor that fits well and is well centered so that the commutator revolves true, is quite important. We use a very sharp tool of no particular design and feed it very lightly, going over the commutator several times and feeding still lighter on the finish. We then polish with fine sandpaper using a slow lathe speed.

Chief Electrician, A. C. BARKER.
W. S. Libbey Co.,
Lewiston, Me.

* * * *

Answering H. H., the cutting tool should be set at an angle of about 45 deg. and slightly above center. Use a sharp diamond-shape tool and have the commutator turning rapidly. Take a fine cut and when all of the flat places are gone, take an extra fine cut. Then file with a bastard file so as to remove the tool marks on the commutator.

Before the polishing process is started the commutator must be slotted, so as to remove high mica. Then go over the whole commutator to see if there are any burrs that will short some of the segments.

Next take No. 0 sandpaper to start polishing the commutator and give the final polish by using No. 00 sandpaper with a little oil on it.

HARRY J. ACHEE.
Chief City Electrician,
Woodward, Okla.

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In turning commutators, I use a diamond-pointed tool, that is ground to about 50 or 55 deg. and rounded up with an oil stone. There should be about 12 or 15 deg. clearance. The ⅜-in. square tool steel can be ground properly and used for this purpose.

The tool must always be set at the center of the commutator, or above, because copper is very tough and will drag. The tool will also drag if the clearance is not sufficient. It is possible to cut copper at almost any reasonable speed, but if too slow a speed is used good results will not be had.

It is good practice to slightly round the ends of the bars, and this can also be done with a fine mill file. After the commutator is turned I use a mill file, giving the file strokes a rolling motion.

Some mechanics use oil with sandpaper for polishing, but this is not good practice, as any electrical manufacturer will tell you. I use sandpaper after filing, but no oil. After the sandpaper has been applied, the commutator can be given a fine polish with the hand, a muslin cloth, or a piece of drilling.

GRADY H. EMERSON.
Asst. Chief Electrician,
Alabama Fuel & Iron Co.,
Birmingham, Ala.

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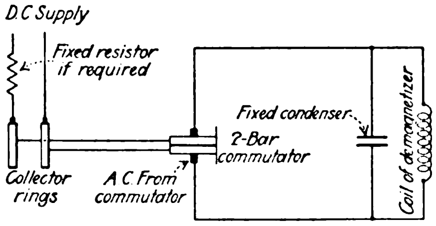
Operating A.C. Demagnetizer on Direct Current.—Will some reader please tell me of a cheap and simple way of changing a 110-volt a.c. demagnetizer so that it can be operated by direct current at the same voltage.

Norristown, Pa. C. D. H.

It will be necessary for C. D. H. to provide means for reversing the direct-current supply. This may be done by mounting two collector rings and a commutator on a shaft, either at the end of the shaft of a small motor or



Method of exciting a demagnetizer from a d. c. power supply.

A two-bar commutator is connected through slip rings to the d.c. power supply. By revolving the commutator at a good rate of speed a supply of alternating - current is obtained for the demagnetizer. Resistors and condensers are used as shown to reduce sparking at the commutator.

on a shaft mounted in two bearings, which may be belted or coupled directly to a driving motor. The commutator can be made of two parts separated by an insulated break wide enough so that the brushes will not overlap and cause a short-circuit between the parts. If the direct-current supply is fed to the collector rings, an alternating current will be obtained from the commutator.

It may be necessary to insert a resistor, made up of one or more lamps, or a fixed resistance, in the collector ring to limit the current. A small condenser should also be connected across the demagnetizing coil to cut down and reduce the sparking at the commutator. A telephone condenser will usually be sufficient for the average coil.

It is possible to use an electrolytic interrupter of the Wehnet type, but the writer has not found one of these to be satisfactory if very much current is to be handled.

C. OTTO VON DANNENBERG.
Designing Engineer,
Sanderson & Porter,
Springdale, Pa.

* * * *

Answering C. D. H., a demagnetizer, which is nothing more than a coil of wire wound on a suitable supporting frame will magnetize a piece of steel if direct current is passed through the coil. If alternating current is passed through the coil the piece will be demagnetized. This is because the alternating current causes the steel to be magnetized first in one direction and then in another at each alteration, and as the piece is withdrawn from the demagnetizer the magnetism becomes less and less at each alteration, so that when the piece of steel has been entirely removed from the magnetic field it will be demagnetized.

From this C. D. H. will readily see that a demagnetizer cannot be operated as such on direct current; instead of changing the demagnetizer, it will be necessary to obtain alternating current.

This can be done, if the expense is justified, by mounting two collector rings on the shaft close to the commutator of a small d. c. motor. Connect one ring to one commutator bar and the other ring to a bar which is directly opposite, or half-way around the commutator. A suitable brush should be placed on each collector ring. By running the motor from a d. c. supply, alternating current for operating the demagnetizer can be obtained from the collector rings, through the brushes.

Longview, Wash. W. L. HARTMAN.

* * * *

What Kind of Wire Should Be Used Used?—We are having considerable trouble from grounds and shorts due to the insulation failing on the wires running from our pyrometers to the indicating and recording mechanisms. The pyrometer points are located in the stills and furnaces of a refinery, and the indicating instruments are 200 to 300 ft. away. Consequently, the wires are subjected to considerable heat at one end of the line while the other end is cool. The wires are carried in conduit and we have trouble with condensation in these pipes. Ordinarily rubber-covered, double-braid wire rots out in less than six months. The so-called "flameproof" wire has not proven satisfactory in this application. Can any reader tell me what I can do to correct this trouble?

Tulsa, Okla. L. A. N.

In reply to L. A. N.'s question in a recent issue of INDUSTRIAL ENGINEER, I wish to say that we are using asbestos-insulated wire in conduit, in several pyrometer installations operating at high temperature and have not had any failures in five years. This wire was furnished by the Brown Instrument Company, Philadelphia, Pa.

Chief Electrician, J. S. MURRAY.
Follansbee Brothers Company,
Toronto, Ohio.

* * * *

I would offer the following suggestion to L. A. N. as a remedy for the trouble that he is having. Three years ago we had similar difficulty; our trouble was caused, apparently, from condensation due to warm air entering one end of the conduit and as this warm air strikes the cold section of the pipe, moisture is bound to form on the conductors and on the inside of the conduit, causing the trouble.

To remedy this we plugged both ends of the conduit using plaster of paris. This stopped the passage of air and we had no further trouble.

Chief Electrician, A. C. BARKER.
W. S. Libbey Co.,
Lewiston, Me.

Increasing Thickness of Slot Insulation.—I have a 3-hp. Allis-Chalmers induction motor that is connected two-parallel star. The motor has 48 slots and 48 coils consisting of 25 turns of No. 16 double-cotton-covered wire and is rated at 220 volts, 9 amp., 1,200 r.p.m. This motor gets very hard service, although the load is not excessive, and I would like to decrease the size of wire in it. What change would have to be made in the pitch if No. 17 double-cotton-covered wire were used to
San Diego, Calif. E. A. F.

In reply to E. A. F., I suggest that instead of changing the size of wire from No. 16 d.c.c. to No. 17 d.c.c., he use No. 16 s.c. enameled wire. With this change it is possible to increase the slot insulation 15 mils.

If it is desired to use No. 17 d.c.c. wire, the only noticeable difference will be a slight temperature rise of 3 to 5 deg. C. The coil pitch need not be changed but in case it is, then the number of turns per coil must also be changed.

I have found it good practice to use a total of 40 mils of slot insulation for stators up to 25 hp. operating at 440 volts. This insulation consists of one 25-mil thickness of oiled canvas and another 15-mil thickness of leatheroid or fishpaper.

San Francisco, Cal. P. P. SCRIBANTE.

* * * *

Answering E. A. F.'s question about increasing thickness of slot insulation, it will not be necessary to change the winding pitch. If the winding pitch is changed, it will slightly increase or decrease the speed of the motor. Single-cotton-covered and enameled wire will give more room in the slots and will not deteriorate as rapidly as d.c.c. wire under hard service. Decreasing the size of the wire in this case from No. 16 to No. 17 will decrease the horsepower of the motor to a small extent.

The top and bottom layers of the coils in the same slot should be separated with a fibre strip 1/12 or 1/16 in. thick. Between the coil layers at the ends, phase insulation, fishpaper or empire cloth, should be used. In the bottom of the slot a strip of 1/16-in. fibre should be placed and for slot insulation, fishpaper and empire cloth should be used. HARRY J. ACHEE.

Chief City Electrician,
Woodward, Okla.

* * * *

Replying to E. A. F. it is not entirely clear to me just what he has in mind by saying the motor is subjected to severe service with no overload, unless severe vibration takes place. However it is not necessary to change the connections or the pitch, if he decides to change the size of the wire.

Not knowing the particular use of the motor it is difficult to understand why the size of the wire should be changed, as my experience with Allis-Chalmers motors leads me to believe that the slot insulation is suitable for the voltage at which the motor is expected to operate. Slot insulation consisting of one piece of 0.015-in. untreated fishpaper, and one piece of 0.010-in. empire cloth is adequate for 220 or 440 volts. It is not always the amount of insulation that is used, but rather how it is used that produces results. I assume that the motor was burned out and perhaps the slot insulation being burned through was the cause of the burnout. There might be a possibility that it was caused by loose wires or dirt in the cell, and when the arc started, it burned through to the iron.

I would consider the motor of much less value if the size of the wire were reduced. My advice would be to rewind the motor according to factory specifications, then give the coils a good soaking in clear baking varnish and when this is thoroughly baked in, apply black baking varnish until it runs clear through the coils in the cells. If you have a megger the winding should be baked until it tests 100 megohms and when it becomes cold the exposed parts of the coils should be coated with black, oilproof varnish, to make a real job with no loose wires. A motor treated this way is almost dirt- and water-proof.

If you have no oven, place a heater inside the motor and close the ends, but do not cover the motor up. Above all things, be sure that the first varnish is thoroughly dry before applying the black varnish, as two distinct coats are much better than two varnishes blended together, as would be the result if the first was not perfectly dry.

Longview, Wash. C. L. HARTMAN.

* * * *

In answer to E. A. F., I would suggest that he use No. 16 B. & S. gage s.c.e. wire, which will reduce the amount of wire insulating material and permit the use of thicker slot cells.

The present winding has 50 No. 16 d.c.c. wires per slot and the insulated diameter of No. 16 d.c.c. wire is 0.0598 in., while that of No. 16 s.c.e. wire is 0.0573 in. or a difference of 0.5098—0.0573 = 0.0025 in. per wire. Arranging the 25 wires per coil in a square, five wires wide by five deep the width and depth with No. 16 d.c.c. wire would be 0.299 in. Likewise the insulated width and depth of 25 No. 16 s.c.e. wires would be 0.2865 in. or a saving in slot width of 0.2990—0.2865=0.0125 in., and 2×0.0125=0.025 in. of slot depth using the same size wire with a different covering.

Checking further, the present winding is connected two-parallel-star for 220 volts. Then a series-star connection would change the line voltage to 440 volts with 25 turns per coil. Now, we know that a delta connection requires more turns of a smaller wire than the star connection, and that 25 turns per coil with a series-star connection requires a line voltage of 440, or volts per phase equals 440÷1.73=254.

Using 25 turns and a series-delta connection the line voltage would have to be 254 volts, but owing to the fact that this motor is to operate on 220 volts, the turns per coil will have to be decreased as follows: The series-delta turns per coil equal (220×25)÷254=21.65 or 22, and the size of wire has to be increased in the same proportion as the turns are decreased. No. 16 d.c.c. wire has an area of 2,600 circ. mils while the area of the new size equals (25×2,600)÷22=2,954 circ. mils. The nearest size is No. 15 with 3,250 circ. mils, which would fill up the slot more than the present winding.

However, the new size, with an area of 2,954 circ. mils is only 2,954—2,600 or 354 circ. mils smaller than the No. 16 d.c.c. wire of the original winding. Accordingly 22 turns of No. 16, d.c.c. wire connected series-delta are better to use than 25 turns of No. 17 d.c.c. wire in series-delta, since the latter has an area of 2,030 circ. mils, or a difference in area between No. 16 and No. 17 of 2,600—2,030=570 circ. mils. Judging from these facts, the best winding for this motor for normal rating would be 22 turns of No. 16 s.c.e. wire with the same coil pitch and connected series-delta for 220 volts.

The use of 22 turns per coil means six less turns per slot which, with the room gained by using single-cotton-covered and enameled wire will allow the use of thicker winding cells. The coil pitch does not affect the size of wire except on very close designs where the chord factor changes the number of effective turns, which varies the torque and the current required to produce it.

The above winding will meet the conditions E. A. F. requires and will be found satisfactory under load.

Wilkinsburg, Pa. A. C. ROE.

* * * *

Calculation of Rotor Winding for Squirrel-Cage Motor.—I have a 1-hp., 220-volt, Type RI, single-phase, General Electric motor, which I wish to rewind for three-phase operation. I have calculated the winding for the stator, but do not know how to go about figuring the squirrel-cage winding for the rotor. Can any reader give me some help in this matter?
Oakland, Calif. B. B.

In reply to the question by B. B. about changing a single-phase motor to three phase, the rotor need not be considered other than to see that it has approximately 80 per cent of the amount of copper, or its equivalent, used in the stator. It is true that definite rules govern the design of squirrel-cage rotors as to the amount of copper, centrifugal force and so on, but good results have been obtained on the above basis.

As an explanation of the term "equivalent" I refer to the fact that the conductivity of cast copper is about 80 per cent of that of the rolled copper used in the stator, while a cast-brass squirrel cage has about 20 per cent of the conductivity of the rolled copper. The squirrel-cage winding includes both bars and rings.

A fair idea of the relations existing between the three-phase and single-phase designs can be obtained when a squirrel-cage three-phase motor is operating from a single-phase circuit. It can be loaded up to about two-thirds of the three-phase value, if the terminal voltage is increased slightly, or to approximately 60 per cent of the three-phase value with no change. In this event the exciting current will be very high and be likely to approach twice its normal value.

West Allis, Wis. EDWARD JAMES.

Electrical Service

around the works

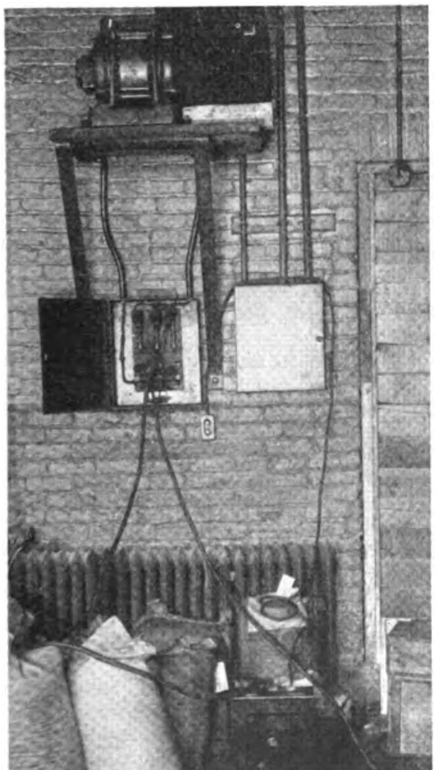
For this section short articles describing ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing, and emergency or special installations.

Handy Portable Starting Device for A.C. Motors

IN COMPLYING with a recent request from a manufacturer for a portable starting device for use with three-phase a.c. motors rated from 1 to 5 hp. and used on machines assembled in his plant, it was necessary to furnish a special magnetic switch formerly used for demonstration purposes.

Mounted on each column throughout this manufacturer's plant was a fused line switch for starting the motors under the old system. In operation, the line test clips on the magnetic starting switch are fastened to the bottom terminals of whichever one of these fused switches is most convenient, and the motor test clips connected to the motor which it is desired to operate, as shown in this illustration.

Because of the size of the driven machines it was necessary to allow about 30 ft. of space around each one while it was being assembled. For that reason a push button with a piece of three-conductor cable long enough so that it could be taken to that part of the machine where it was most needed, saved considerable time. This arrangement enabled the operator to carry the starter to the nearest line switch, clamp on the test clips, push the button and operate the machine easily and conveniently.



The magnetic switch of the starter is connected to the motor line switch and operated by the push button.

Such a scheme could be used to advantage by assemblers or inspectors, in other plants, as it would enable them to keep a close watch of all bearings and rotating parts during a test run and to stop the machine almost instantly in case trouble should develop.

Industrial Control Dept., E. B. SMITH.
General Electric Co.,
Cleveland, Ohio.

Ammeter Indicates Single-Phase Operation of Motors

IN RECENT issues of INDUSTRIAL ENGINEER I have noted several articles regarding the single-phase operation of three-phase motors. Perhaps the following experience may prove to be of interest to some of our readers.

One morning I was called to one of the mill departments by the department superintendent to find out why one of his motors showed such a high reading on the ammeter. As there were other motors running on the same line at the time we naturally thought of an overload at first, but found that all the connected machines were running normally. Then single-phase operation was thought of, but after the motor had been stopped it started again promptly; so the possibility of single-phase operation was dismissed for the time being.

There are three motors, one 50-hp. and two 20-hp. motors, running on the same branch circuit from the main distribution panel, all on one set of fuses, and under those conditions we were unable to understand the behavior of the ammeter. A few minutes later we had occasion to shut down all three of the motors and the cause of the trouble was immediately apparent when we attempted to start again—one fuse was blown.

Two of the motors had an ammeter mounted on their starters. One of these ammeters read high, while the other ammeter, which happened to be in a different phase read low. What happened was that the 50-hp. motor had been started first; then the two 20-hp. motors had been started. During this operation the fuse had blown, but as the 50-hp. motor was running it supplied current for the others and enabled them to be started. As soon as all three motors were shut down it was impossible to start any of them. After the fuse was replaced the motors all started and ran perfectly, the ammeters showing normal readings.

Single-phase operation is difficult to detect with only one ammeter, unless it is arranged with a meter switch so that the current can be read in all phases. Two ammeters will immediately locate the trouble as will also two single phase wattmeters.

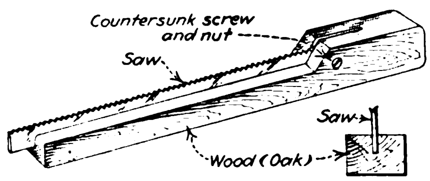
If located in a quiet place single-phase operation can be detected by the peculiar hum of the motor, but in a noisy location no difference can be detected. A speed check is worthless as the change in speed is too small to be of any particular benefit in diagnosing the trouble. Of course, if the motor is left running long enough the coils will become unduly hot in one phase and thus disclose the trouble, but the insulation may be damaged.

Chief Electrician, LEE F. DANN.
Donnacona Paper Co., Ltd.,
Donnacona, Que., Can.

Wooden Stiffener Permits Use of Hacksaw Blade in Close Quarters

IN ELECTRIC wiring and installation work it is often necessary to use a fine-toothed hacksaw blade for cutting off bolt ends, laths inside plastering, cutting cable in confined places, for cutting off pipe conduit placed between floors and in walls and for other uses. Often the work must be done in a corner where it is not practicable to use a hacksaw frame. In such cases it is often possible to greatly increase the facility of cutting with the unsupported saw blade by means of the slotted wooden handle or backing shown in the accompanying drawing. This saw stiffener is used for all such work by one electrician.

The stiffener consists of a piece of oak, slightly longer than the blade, with a slot in one side, into which the saw blade is pressed. The blade is



This wood stiffener makes it easier to use a hacksaw blade in close quarters.

held in the handle by a short bolt with countersunk head and nut. If the slot is made off-center it is possible to get closer to the edge. Also, if the end of the blade is broken off it is possible to get about ½ in. closer into a corner where it is necessary to use only the end of the blade to make the cut. Such a stiffener holds the blade straight and rigid and permits a good, substantial cutting pressure to be applied. A similar stiffener, which would take up less space, could also be made by bending a piece of flat steel to fit on the back of the blade.

Washington, D. C. G. A. LUERS.

Armature Trouble Caused by Opening Field Circuit of Shunt Motor

THE repair foreman at a coal mine was puzzled at the sudden marked increase of burned-out armatures coming to the shop. Investigation failed to locate the trouble for some time, although it was noticed that the motors were coming from the coal-cutting machines. Finally it was ascertained that the operators had discovered that by opening the shunt field circuit temporarily on the motor as soon as the knife was started into the bed of coal, they could speed up the operation to their own gain and the company's expense. Naturally, the armatures did not stand this treatment indefinitely.

The speed of the motor was controlled by a drum controller. Normally, when once the 10-ft. extension arm was started into the bed of coal, the controller was placed on nearly the last notch until the arm had swung nearly through its range. However, as the field leads came outside of the housing which enclosed the motor and were joined by a connector in which the ends of the wires were held by setscrews, the operators had got in the habit of throwing the controller over to full speed and then slipping one of the field leads cut of the connector until the cutter had almost completed its swing.

Boulder, Colo. HAROLD E. BENSON.

How to Determine Power Factor With the Aid of a Watt-Hour Meter

THE subject of system power factor is daily becoming more interesting to the plant engineer. Many who would like to determine and check this value from time to time, are held back only by a lack of the proper instruments.

It has been my experience that almost all plants are equipped with at least one voltmeter and ammeter, but are not always so fortunate as to have in their possession some of the more expensive instruments, such as wattmeters, power factor meters, and the like. However, I have repeatedly used the method of power factor determination outlined below, with very good results. The only instruments required are a voltmeter, an ammeter (with current transformer if necessary), and the watt-hour meter installed at the service switch.

There are in use today, several types of watt-hour meters, but for our purposes they may be divided into two classes: Those in which the rotating element is visible and those in which the rotating element is enclosed so that it is not visible. This latter type is not so convenient to use in figuring wattages, but equally good results may be obtained from the use of either. The first of these methods may be used with any type of meter; the second can be used only when the meter has the rotating element visible.

Connect the ammeter into one phase so that it will measure the entire current flowing through one pole of the service switch. Across this same phase connect the voltmeter. Now determine the number of kilowatt-hours represented by one division of the dial located at the extreme right of the dial plate. If the meter is small, it will in all probability read directly in kilowatt-hours. The larger meters require that the dial reading be multiplied by a certain constant in order to obtain the kilowatt-hour reading. This constant appears on the face of the dial plate.

Having determined the kilowatt-hour equivalent of one scale division, observe the time in minutes required by the pointer to travel over this distance. While making this observation, take readings of the voltmeter and ammeter at regular intervals of one or two minutes.

We now have found a definite number of kilowatt-hours, consumed during a definite interval of time expressed in minutes. Convert this result into kilowatt-hours per hour, by means of the equation:

(1) Kilowatt-hours per hour=(kilowatt-hours measured÷time interval in minutes)×60=kilowatts.

The numerical result obtained from equation (1) is also the average number of kilowatts that were being consumed at any instant during the test.

The average current that was flowing during the test may be found by adding together all the readings of current taken and dividing the result by the number of readings. The average voltage may be found in like manner.

The number of kilovolt-amperes consumed at any instant during the test is then:

(2) Kva.=(average current×1.7×average voltage)÷1,000.

The power factor, expressed as a percentage, may now be found from:

(3) Per cent power factor=(kilowatts÷kilovolt-amperes)×100. In this equation the kilowatts are obtained from equation (1) and the kilovolt-amperes from equation (2).

If the watt-hour meter in question is one having a visible rotating element, the method may be changed somewhat, and the time necessary to determine the power factor considerably shortened.

From the manufacturer's data, or from the meter department of the local central station, obtain the watt-hour constant for the particular type of meter used. This watt-hour constant is simply the number of watt-hours of energy recorded on the meter when the disk makes one complete revolution.

If the information is not easily obtainable, it may be determined experimentally by observing as before, the time interval required by the meter to register a definite number of kilowatt-hours. During this interval take regular readings of the speed of the disk. Determine the average number of revolutions per minute, and find the constant by the equation:

(4) K=[observed number of kilowatt-hours÷(average r.p.m.×time in minutes)]×1,000.

The constant, having once been determined for a certain meter, may be recorded and used for all future calculations.

The watts passing through the meter may be calculated from the standard meter formula:

(5) Watts $= (3{,}600 \times K \times R) \div S$,

In which:

K=watt-hour constant.

R=number of revolutions of the disk.

S=time in seconds required for R revolutions.

The average current and voltage during the time S may be noted as before, and the kva. then calculated from equation (2).

Power factor is found by the following equation:

(6) Per cent power factor=[(watts÷1,000)÷kilovolt-amperes]×100.

As an aid in following these methods, there is here included an actual example.

A three-phase, 1,200-amp., 550-volt, service switch, has mounted on its panel a Thomson (General Electric) watt-hour meter, type D-3. The meter is rated at 800 amp. when connected through a current transformer of ratio 800 to 5. A voltmeter is connected across one phase and an ammeter with a scale reading from 0 to 5 is cut in on the same phase through a current transformer of ratio 1,200 to 5 (240-1). The watt-hour meter readings must be multiplied by 400 to obtain kilowatt-hours.

By observation it was found that the pointer traversed one division of the right-hand dial in exactly 60 min. The average reading of the ammeter during that time was found to be 2.3 amp. and the average reading of the voltmeter, 601.7 volts. Then by equation (1), Kw-hr. per hr.=(400÷60)×60=400.

Current in one phase=2.3×240=552 amp.

By equation (2)

Kva. $= (552 \times 1.7 \times 601.7) \div 1{,}000 =$ 564.7.

By equation (3)

Per cent power factor= (400÷564.7)×100=70.8. During the above test, the average r.p.m. of the disk was observed to be 14. Then by equation (4)

K=400÷(14×60)×1,000=476.

And by equation (5)

Watts $= (3{,}600 \times 476 \times 14) \div 60 =$ 399,840.

The value of kva. will be the same as that used in the previous method, since all readings were taken at the same time. Then by equation (6)

Per cent power factor=[(399,840÷1,000)÷564.7]×100=70.8.

These methods are, of course, based on the assumption that a balanced load exists in all three phases. This condition practically exists in a plain three-phase motor load.

It will be seen that the result obtained by the first method is quite similar to that obtained by the other. Greater accuracy than a result correct to one decimal place can not be expected.

It is interesting to note that the true watt-hour constant for this meter is 480; this value checks very closely with that obtained by experiment, the percentage of error being less than one per cent. JAMES P. MARSHALL.
Electrical Engineer,
Cambridge Rubber Co.,
Cambridge, Mass.

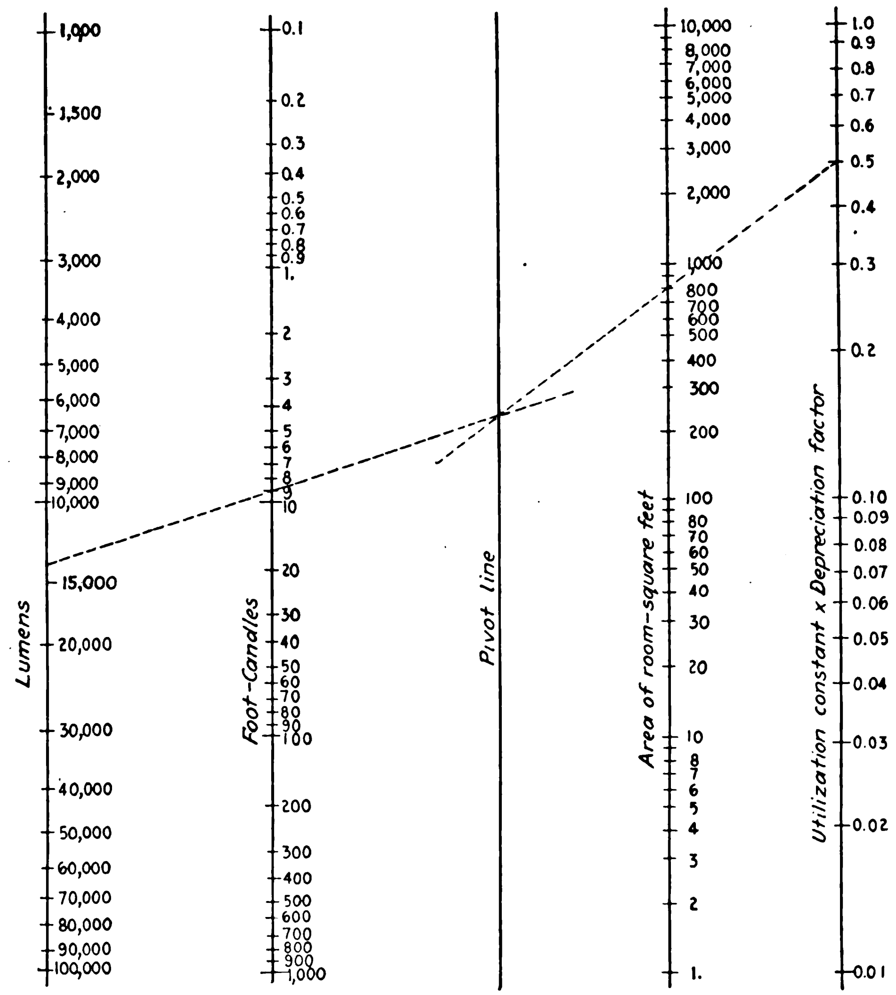
Handy Chart for Determining Lighting Requirements

THE accompanying chart may be used for calculating illumination requirements when it is necessary to determine the utilization constant or co-efficient from the character of the room to be lighted. The factors which must be taken into consideration are: color of walls and ceiling, mounting height of lamps above working plane, type of reflector, and distance between lamps. The accumulation of dirt and ageing of the lamps make it necessary to assign values ranging from 75 to 85 per cent for the depreciation factor. Tables covering lighting requirements may be found in the Standard Handbook for Electrical Engineers, or may be obtained from manufacturers of lighting equipment who supply literature concerning their reflectors and fixtures. Several states have codes which specify minimum requirements for intensity of illumination for different locations; consult the Standard Handbook for these.

To use the chart it is necessary to find the utilization constant and depreciation factor, which should be multiplied together. The area of the room is determined and a straight-edge placed on the chart so that it will intersect the Area scale and the Depreciation scale at the points corresponding to these values. Note the point where the straight-edge intersects the Pivot line (center scale). The straight-edge is then shifted so that it intersects the Pivot line at the point previously noted, and the Intensity in Foot-candles scale at the desired value. The intersection of the straight-edge with the Lumen scale, at the extreme left, shows the total lumens required. To find the lumens per outlet, divide the total lumens required by the number of outlets and note the value obtained for determining the size of lamps that should be used. The number of lumens to be obtained from various sizes of lamps will be found from the accompanying table above, which was taken from the Standard Handbook.

This chart will simplify the calculations involved in laying out a lighting system.

Assume that utilization constant times depreciation factor=0.5; area of room=800 sq. ft.; foot-candles desired=9. Place a straight-edge so that it will intersect the area scale and the depreciation scale at the above values. Note the point of intersection with the pivot line. Then place the straight-edge so that it intersects the pivot line at the point noted, and the foot-candle column at 9; read the value of lumens required, 14,400, at the point of intersection on the lumen scale. The size of lamp to be used can be determined from the table.



Illumination Ratings of Mazda C Lamps

Size of Lamp in Watts	Lumens
50	450
75	865
100	1,260
150	2,040
200	3,100
300	4,840
400	6,700
500	8,750
750	13,900
1,000	19,300

CHARLES F. CAMERON.
Rock Springs, Wyo.

Heating Caused by Carrying Each Phase of 3-Phase Circuit in Separate Conduit

CURRENT for the various "sets" in a large moving picture studio was delivered from the three-phase transformers to the switchboard buses at 110 volts. Four 500,000 circ. mil cables for each of the three phases served as the jumpers connecting the transformers and buses; each phase, comprising four cables, was carried in a separate conduit.

When a large number of the sets were being used these conduits became very hot, thus threatening deterioration of the insulation. At no time did the cables themselves carry capacity load, as was shown by checking the load with an ammeter.

Heating of the conduit was assumed to be due to the eddy currents induced in it by the single-phase currents carried by the four jumper cables. That this assumption of the cause was correct is evidenced by the fact that later when extensions were made to the plant and the switchboard buses were revamped, the jumper cables were reconnected so that each conduit carried three-phase current instead of single-phase.

As there were then four cables in each conduit to carry the necessary current and it was desired to use these, besides saving the labor of pulling out the four old ones and pulling in three new cables of the same or slightly greater current-carrying capacity, an extra single-phase cable was left in each of the three conduits.

After reconnecting to the buses, there was still an unbalance of single-phase current in each conduit, but this unbalance was only one-fourth of what it was originally when there were four single-phase cables per conduit. Under the new conditions the conduit hardly heated enough to be noticeable, with the "sets" all pulling full load.

Oakland, Calif. S. H. SAMUELS.

Improper Connections to Motor Cause of Unusual Performance

A SLIP-RING motor rated at 250 hp., three-phase, 60 cycles, 440 volts, 490 r.p.m., which was installed in an aluminum rolling mill, gave indications of overload immediately after its installation. A portable wattmeter connected into the supply circuit at the main switch indicated practically full load when sheets were passing through the rolls. The wattmeter also indicated two-thirds load with no material passing through the rolls. Another peculiar fact was that with the frequency normal, the motor ran at only 1 per cent slip instead of the rated 4 per cent slip.

The electrician who connected the motor was not on hand at the time these peculiar symptoms were noted and as the wiring was concealed in a large metal conduit imbedded in the floor, a superficial inspection failed to indicate the nature of the trouble.

The solution was finally found by means of our old friend, the voltmeter. The nameplate of the motor gave the rated voltage between the collector rings as 380 volts. The voltmeter, when connected across two rings, showed 440 volts. This reading checked with the voltage given at the control panel. Apparently the electrician had connected the rotor to the supply lines, and the stator to the resistance.

This assumption was found to be true when the wiring from the control panel was uncovered and the connections traced. With the proper reconnection of the motor wiring, the motor carried its load without heating, the speed returned to normal and the wattmeter indicated the true load on the motor.

DEAN W. TAYLOR.
Industrial Power Engineer,
Metropolitan Edison Co.,
Reading, Pa.

Specially-Connected Series Motor Substituted for Shunt Motor

RESOURCEFULNESS is a quality that is essential to every plant maintenance man. One of the best ways of developing this much-desired quality is to learn the method by which others have coped with similar difficulties. The following is a good example of the resourcefulness of one plant electrician.

A skelp mill in the Chicago steel district has 11 roll stands. The first seven stands or sets of rolls are driven by a Kraemer adjustable-speed set; the eighth stand, which consists of two edging or vertical rolls, is driven by a 160-hp., 250/500-r.p.m., shunt-wound motor; and the last three stands are driven from a second Kraemer adjustable-speed set. Skelp or strip steel is in all 11 stands at once; hence the necessity of accurate speed adjustment of the different sets of rolls can be seen.

While a 160-hp. motor was used on the eighth or edging stand drive, it was considerably over-motored, only about 80 hp. being required. The speed of the drive was determined by the weight of skelp being rolled, but generally the motor speed was about 500 r.p.m.

One Saturday afternoon the V-rings of the commutator loosened to the point where the commutator exploded; that is, the segments went all over the mill. This accident shut down the entire skelp mill and at once entailed a considerable production loss.

Investigation showed that what could be found of the commutator was damaged beyond repair; also that parts of the commutator had hit the field coils, tearing off portions of the winding. The bands on the armature had been loosened by the accident and the armature winding came out of the slots sufficiently to be jammed in the air gap. The mechanical shock resulting from the accident also broke one of the bearing pedestals; so the motor was more or less of a total wreck. To make matters worse, although there was a spare armature, it could not be used without a good motor frame and the frame on the wrecked motor was damaged more than could be repaired in the 40 hours remaining before Monday morning. At this point the resourcefulness of the plant electrician came into play.

He conceived the idea of using a series-wound motor in place of a shunt-wound, adjustable-speed motor. There were plenty of series-wound, totally-enclosed, mill-type motors available; so the plant electrician decided to install one in place of the wrecked motor. He thought that by connecting the series field of the mill-type motor across the line through resistance, he would be able to get the desired speed.

The requirements of the drive were, as previously stated, approximately 80 hp., at 500 r.p.m. An 80 frame, Type MC Westinghouse mill-type motor has a mill (1-hr.) rating of 80 hp. When used as a series motor it delivers a speed of 500 r.p.m. at this load. This data can be taken from the performance curves of the motor. Since the motor was rated at 230 volts, the line current at this load will be 280 amp. Therefore, to run the motor at 500 r.p.m., with an 80-hp. load, requires a current of 280 amp. in the series field.

In determining the amount of resistance to connect in series with the field so as to place the field directly across the line, the resistance of the field was neglected. Resistance equals voltage divided by current; hence, $230 \div 280 = 0.8220$. Therefore, the amount of resistance required for connection in series with the field would be 0.8220 ohms and the resistance should have a carrying capacity of 280 amp.

The series field was connected in series with a sufficient number of resistance frames, having heavy-duty, cast-iron grids to give this resistance. An ammeter was connected in series with the resistance and the combination was connected across the line through a switch and fuses. The amount of resistance was adjusted until a current of approximately 280 amp. was obtained.

Power was then applied to the armature of the mill-type motor and the combination ran successfully as a shunt-wound machine. After running a few pieces of skelp through the rolls it was found that the speed should be slightly different than at first supposed; so the amount of resistance in series with the series field was changed until the desired speed was obtained.

This combination was ready to start with the Monday morning shift. It was closely watched, however. The first trouble encountered was that the series fields began to overheat. They were designed for an intermittent rating and were being used continuously. So an air hose was put in one of the hand holes to aid in circulating cooling air.

Although the motor overheated considerably, it ran successfully throughout the week. At the end of the week, it was decided to put in the next larger frame of motor in order to obtain a performance that could be depended upon until a new motor was obtained.

A 230-volt series-wound, 90 frame, Type MC, totally-enclosed, Westinghouse motor delivers 100 hp. at 500 r.p.m. on the mill or 1-hr. rating. At 230 volts a current of 350 amp. is required for this load. With the series field shunted across the line, a resistance of $230 \div 350 = 0.656$ ohms is required to limit the field current to the 350-amp. value.

The 90 MC motor was installed with a resistance of 0.656 ohms, and having a continuous carrying capacity of 350 amp. The larger motor required an air hose to help keep the fields cool; however, this motor ran satisfactorily for two and one-half months, until the regular shunt motor was installed.

Indiana Harbor, Ind. A. J. W.

Mounting Transformers on Skid Facilitates Testing Out New Machines

THE problem of providing current of the various voltages and cycles necessary in testing out new equipment, which is fitted with a special motor to suit the customer, is well handled by one special machine manufacturer. The voltages of these motors are usually 110, 220 or 440. Power is purchased at 220 volts, 60 cycle. Power outlets are located at convenient points throughout the plant. Also, a motor-generator set will provide direct current which is put through a special test board to give various voltages desired.

To get 110- or 440-volt, 60-cycle, alternating current, use is made of two, pole-type, distribution transformers, which are placed on a skid or platform handled by an elevating-platform, hand-lift truck, so that they can easily be taken to any part of the plant. One transformer is connected up to step the 220-volt supply down to 110 volts. The other transformer is connected to deliver 440 volts, on the secondary side.

If a motor is rated at any one of these voltages, it is tested at full load. In case the motor is of an odd voltage or odd number of cycles, as for example 550 volts, 25 cycle, it is tested at 440 volts, 60 cycle, but the machine is operated without load. If the motor will satisfactorily operate the machine empty, the manufacturer is willing to accept the responsibility of the design being correct, so that it will operate properly under full load. The main point is to be sure that the machine will operate smoothly and will not bind or stick at various points in its travel.

Mechanical maintenance of

Power Drives

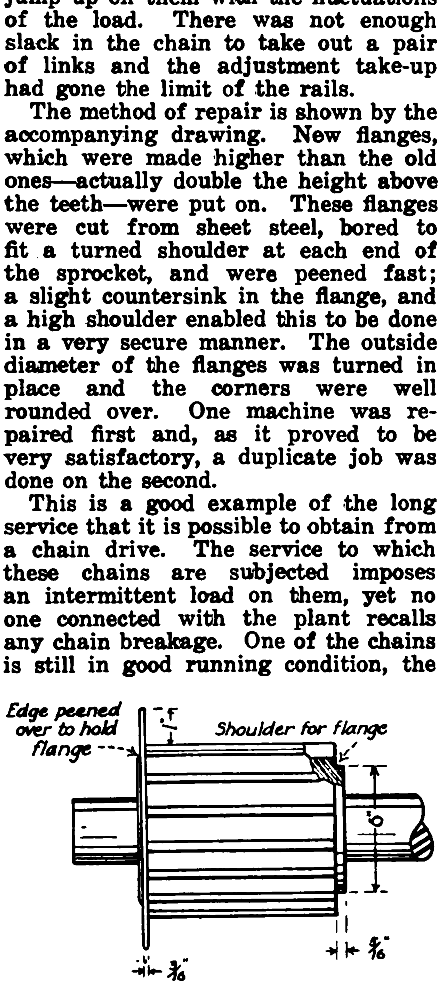
This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through the auxiliary transmitting equipment to all driven machines.

Repairing Worn Flange on Pinion of Chain Drive

IN a plant built in 1902 the two a.c. generators are supplied from two 220-volt, 200-amp. exciters with Link-Belt silent chain drives, 6 in. wide and 1 in. pitch. Twice in their life of usefulness, the bearings of these exciters have been rebabbitted. The last time the bearings were out, the armature shafts were taken out and the commutators lathe-turned and undercut. However, the principal reason for shopping the equipment was to repair the sprockets. The chains used depend upon flanges at the ends of the sprockets to keep them from running off. These flanges were so badly worn and low that the chains would occasionally jump up on them with the fluctuations of the load. There was not enough slack in the chain to take out a pair of links and the adjustment take-up had gone the limit of the rails.

The method of repair is shown by the accompanying drawing. New flanges, which were made higher than the old ones—actually double the height above the teeth—were put on. These flanges were cut from sheet steel, bored to fit a turned shoulder at each end of the sprocket, and were peened fast; a slight countersink in the flange, and a high shoulder enabled this to be done in a very secure manner. The outside diameter of the flanges was turned in place and the corners were well rounded over. One machine was repaired first and, as it proved to be very satisfactory, a duplicate job was done on the second.

This is a good example of the long service that it is possible to obtain from a chain drive. The service to which these chains are subjected imposes an intermittent load on them, yet no one connected with the plant recalls any chain breakage. One of the chains is still in good running condition, the other is to be renewed, and both sprockets are as serviceable as new, although the tips of the teeth are rounded instead of clean cut as they were at first. DONALD A. HAMPSON.
Plant Superintendent,
Morgan & Wilcox Mfg. Co.,
Middletown, N. Y.



The old flanges, which had worn too low to retain the silent chains on the sprockets, were replaced by these disks.

Where and Why Lineshafts Break in Service

TRANSMISSION shafting carrying driving or driven pulleys or rope sheaves as a general rule break just inside the hub of the pulley. The reason for this is not hard to understand. A shaft that carries pulleys and transmits power is subjected to two main forces tending to disrupt it. The principal one of these forces is that of twisting, caused by the turning of the shaft. The result of this force is called the twisting moment; and if we assume a length of shaft between any two hangers and with no pulleys thereon, this twisting moment will be the only force to which the shaft is subjected, neglecting the weight of the shaft. The load on the shaft will be that due to the amount of horsepower that is being transmitted.

If now we consider a length of the shaft between two hangers, but which has a pulley located on it at some place, we have a different condition. Forgetting for the moment that the shaft revolves, we can consider the shaft as a beam loaded at some point with a concentrated load, the pulley in this case being the load. This condition tends to deflect the shaft just as in the case of a beam, or in other words to create a bending moment. If the pulley or sheave is midway between the bearings this bending moment will be a maximum. As the location of the pulley moves nearer either hanger the bending moment decreases.

A shaft in motion carrying pulleys is, therefore, subjected to a combined twisting and bending moment which is greatest in the hub of the pulley, and it is for this reason that shafts break at this place. If the belt is put on so tightly that the shaft is deflected, as is often the case, there will be an additional bending moment caused by this condition.

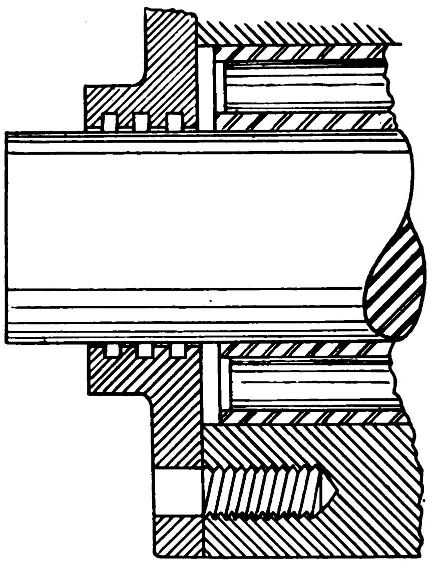
The fact that shafts tend to break in the pulley hubs, rather than elsewhere, is an advantage in one way since they usually give warning before they disrupt completely, and thus avoid wrecking the transmission equipment or the machinery that is beneath. The breaks are not as a rule sudden and complete, but start at the outer surface and progress gradually across the shaft. In the meantime there will be indications of trouble. The belt may tend to run to one side of the pulley; the adjacent bearing may heat; the shaft just outside the hub and sometimes the hub itself may heat; the pulley may wobble; or there may be a grating sound heard at times. Any one of these indications should be investigated as soon as possible after being noticed, as it may mean a broken shaft.

The remedy for such trouble is to use shafting of ample size for the load and locate the pulleys as closely to the hangers as possible; or better still, place a hanger on each side of the pulley. JOHN A. COLLINS, JR.
Lawrence, Mass.

Using Grooved Caps to Prevent Oil Seepage From Roller Bearings

THE customary method of retaining oil in a roller bearing is by using end caps recessed for a felt ring. For example, a bearing on a 2-in. shaft will have the caps recessed so that stock felt washers of 5/16 in. or 3/8 in. square cross-section can be crowded into the space and press upon the shaft. However, unless the washers are changed occasionally they become glazed from the rubbing of the shaft.

There is another method that has much to commend it, but is not so com-



Oil which seeps out from the bearing along the shaft is thrown off into these three grooves.

monly used, which does not require felt or other self-adjusting mediums for making the closure. How this is accomplished is shown in the accompanying illustration. The bearing cap is bored to a diameter 0.01 in. larger than the shaft. This leaves a gap ample for all necessary clearance, but not so great as to cause undue seepage of oil. If the cap for the 2-in. shaft bearing is made long enough to permit cutting three grooves ⅛ in. wide and ⅛ in. deep, as shown, there will be very little loss of oil, as the oil is thrown off as it creeps outward along the shaft, and is caught in the grooves. The oil will be returned to the bearing if a drain hole has been made on the inside. This method of retaining the oil does not lose any of its effectiveness with age, and may be used on any other bearing having an end cap.

Factors in Selection of Speed Reducers of Proper Capacity

ONE of the interesting developments in power transmission during the last few years has been the rapid growth in the use of unit speed reducers and their applications to varied forms of machinery and industrial equipment. Much has been written on this subject in regard to design, features, principles of operation, and construction of the different types and the advantages of unit speed reducers as compared with other forms of speed reduction equipment such as belts and pulleys, chains and rope drives, open gearing, and so on.

To the engineer or plant executive, it is of even greater importance to have fundamental information covering the application of these machines to various forms of equipment, with the basic formulas and a knowledge of their application to practical problems which will enable him to estimate requirements on specific jobs and aid in selecting units of proper type, capacity, and reduction ratios.

The information on spur-gear, speed-reducer calculations presented is applicable to any of the standard types of spur gear reducers now on the market, including the plain, spur, planetary and non-planetary types, and also the herringbone type. Worm-gear reducer problems require a little different handling. It is hoped that the information will prove interesting and helpful to those who are concerned with transmission and speed-reduction problems.

The principal point to be remembered in dealing with speed-reduction problems is that theoretically the same horsepower is delivered by the reducing unit as is delivered to it by the prime mover. The speed, however, decreases through the reducer, depending upon the reduction ratio used, and the torque or twisting moment correspondingly increases. It is necessary to have a clear understanding of this subject in order to make a proper selection of speed reducers to meet a given set of conditions. The various elements which are factors in all speed-reduction problems are as follows:

P=Load in pounds.

R=Radius in inches of drum or pulley.

$2\pi R$=Circumference of drum or pulley (inches).

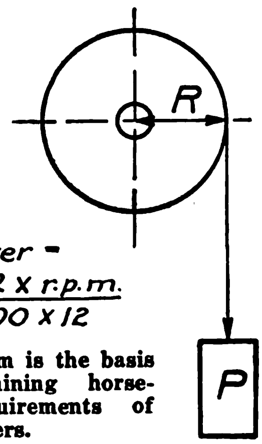
N=Revolutions per minute (r.p.m.).

T=Torque or twisting moment in inch-pounds.

W=Work done.

$Hp.$=Horsepower. (33,000 ft.-lb. per min.)

Torque or twisting moment is that force which tends to produce rotation



Horsepower = $\dfrac{P \times 2\pi R \times r.p.m.}{33{,}000 \times 12}$

This diagram is the basis for determining horsepower requirements of speed-reducers.

in a shaft or pulleys and is equal to the product of the force exerted times the length of the lever arm. T is expressed in a formula (see accompanying illustration): $T=P\times R$.

Work done is equal to the product of the force acting on an object times the distance through which it moves. Thus, where D = distance traveled, then, $W=FD$.

The distance through which the force acts in one revolution is equal to the circumference of the circle, which is $2\pi R$. Therefore, work done in one revolution is: $W=P\times 2\pi R$ in.-lb.

If the drum or pulley makes more than one revolution the total work done will be: $W=P\times 2\pi R\times N$ in.-lb.

Since 1 hp. is equivalent to 33,000 ft.-lb. per min., the horsepower required to revolve the pulley N times per minute against the weight P will be: $Hp.=(P\times 2\pi R\times N)\div(33{,}000\times 12)$.

Other useful formulas are derived from these equations as follows:

$Hp.=(T\times N)\div 63{,}025$.

$T=(63{,}025\times hp.)\div N$.

$T=P\times R$; $P=T\div R$; $R=T\div P$.

By using one or more of the above formulas it is possible to solve practically any speed reduction problem which may be presented; some of the methods used are indicated in the simple problems which follow. Let it be borne in mind, however, that in actual practice, the efficiency of both the reducer and the driven machine must be considered, when selecting reducers of the proper size.

(1) If we have a drum with a radius of 12 in. and a load of 2,000 lb. find the torque necessary to move it.

$T=P\times R = 12\times 2{,}000 = 24{,}000$ in.-lb.

(2) If the drum is to be driven at 1 r.p.m. how much work will be done during one revolution?

$W = 2\pi\times T\times N = 6.28\times 24{,}000\times 1 =$ 150,720 in.-lb.

(3) How many horsepower will be required to drive this drum at 20 r.p.m.?

$Hp.=(2\pi R\times P\times N)\div(33{,}000\times 12) = (6.28\times 12\times 2{,}000\times 20) \div (33{,}000\times 12) = 7.61$ hp.

(4) If we know that the torque on the drum shaft is 24,000 in.-lb. what hp. would be required to drive it at 20 r.p.m.?

$Hp. = (T\times N) \div 63{,}025 = (24{,}000\times 20)\div 63{,}025 = 7.61$ hp.

(5) If 7.61 hp. is required to drive this drum at 20 r.p.m. what is the torque in inch-pounds on the center of the drum shaft?

$T=63{,}025\times hp.\div N=(63{,}025\times 7.61)\div 20=24{,}000$ in.-lb. torque.

(6) If the torque or twisting moment at standing load is 24,000 in.-lb. and radius of drum is 12 in., what is the load on the drum in pounds?

$P=(T\div R)=(24{,}000\div 12)=2{,}000$ lb.

(7) If the torque on this drum shaft is 24,000 in.-lb. and the load on the drum is 2,000 lb. what is the radius of the drum?

$R=T\div P=24{,}000\div 2{,}000=12$ in. radius or 24 in. diameter.

We cannot over-estimate the importance of carefully calculating actual torques on the driven unit, as a basis of determining horsepower required to move the load. This is particularly true in cases where high reduction ratios are used and the final speed is only a fraction of a revolution per minute.

The capacity of the driving unit must always be great enough to compensate for frictional and other losses in the reducing unit and driven unit, and also to start the load on the driven unit, even though the power required while running is much less.

Assuming the conditions for a practical problem, the foregoing formulas may be used as follows to carry the calculation through to the selection of the proper size and type of spur-gear speed reducer for a particular installation. The problem concerns the selection of a motor and reducer for a conveyor with a mechanical efficiency of 80 per cent. The headshaft of this conveyor is to be driven by a spur-gear speed reducer at 25 r.p.m. The total load to be moved is 4,000 lb. The pitch radius of the sprocket driving the conveyor belt is 18 in.; and 800-r.p.m. motor is to be used. The formula for this is:

$Hp. = (2\pi R\times P\times N) \div (33{,}000\times 12) = 6.28\times 18\times 4{,}000\times 25) \div (33{,}000\times 12) = 28.54$ hp.

As the efficiency of the conveyor is 80 per cent, the actual horsepower required will be: $28.54\div 0.80=35.67$ hp.

The efficiency of the reducer is 95 per cent, and so the size of the motor required will be: 35.67 hp.$\div$0.95= 37.55 hp. The reduction ratio is 800 to 25 or 35 to 1.

All that is now necessary is to select from the manufacturer's catalog a speed reducer of a rating and ratio conforming to the above results. In case of doubt, or when an especially difficult problem in connection with an installation operating under severe service conditions is under consideration, it is advisable to consult the Engineering Department of the speed reducer manufacturer.

Chief Engineer, HARRY C. PETERSON.
Foote Bros. Gear & Machine Co.,
Chicago, Illinois.

In the Repair Shop

This section is devoted to repair work on electrical and mechanical equipment. Special attention is given to shop or bench tools and short cuts or improved methods of handling work of this character. Contribution are always welcome.

Rewinding Two-Phase Motors for Three-Phase Operation

FREQUENTLY occasions arise when it is desirable to change a two-phase squirrel-cage motor for three-phase operation. In this case the first thing to do is check the three-phase line voltage with the two-phase winding connected series-star or series-delta. With this information it is a simple matter to determine a suitable three-phase connection with the required number of turns per coil and correct size of wire.

For a specific case we will consider a two-phase, 5-hp., 60-cycle, 220-volt, 1,200-r.p.m. squirrel-cage induction motor which it was desired to change to three phase, with the same horsepower rating, frequency, voltage and speed. The two-phase winding data were, 48 slots and 48 coils wound 23 turns of No. 15 s.c.e. wire, 12 groups of four coils per group, coil pitch 1-and-8, six poles, connected two-circuit.

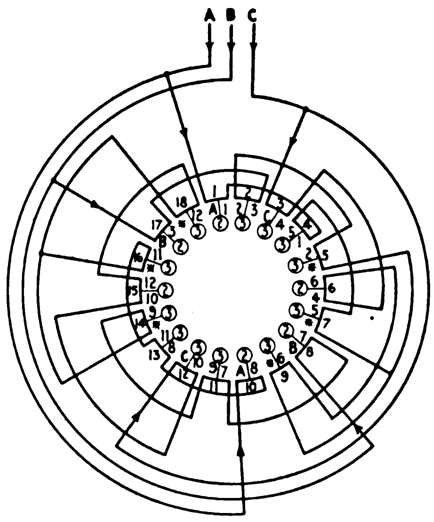
The three-phase, series-star line voltage equals $C\times V_2\times 1.212$ and the three-phase, series-delta line voltage equals $C\times V_2\times 0.707$, where C equals number of circuits in the two-phase winding and V_2 equals the two-phase line voltage. Therefore, the series-star line voltage equals $2\times 220\times 1.212=537$ volts and the series-delta line voltage equals $2\times 220\times 0.707=313$ volts.

From the above results it is obvious that reconnection is not possible; therefore, the next step is to figure a new winding. First, try the series-star winding for a line voltage of 440, as this winding can be connected two-parallel star for 220 volts, and figure the turns for 440 volts, instead of 220 volts. This will keep the turns per coil high and the size of wire small, which is better for winding, as mush-type coils wound with small wire are easy to shape while winding on the stator.

When computing the new turns per coil use the formula, $(T_2\times V_0)\div V_3$, where T_2 equals the old number of turns in the two-phase coil, V_0 the required three-phase line voltage and V_3 the line voltage derived from the voltage formulas given above. In this case the number of new three-phase turns for series-star and 440 volts equals $(23\times 440)\div 537=19$ turns plus and the number of turns for 440 volts, three-phase, series-delta equals $(23\times 440)\div 313=32.4$ or 33 turns plus per coil.

Judging from the number of turns computed, the star-connected winding will give the best results, as the turns per coil are lower and the size of wire larger, but still small enough for a mush-coil that will shape readily. The reason for selecting this winding is that it provides a better space factor, that is, more copper and less insulation, than 33 turns of smaller wire would require.

The new size of wire in circ. mils is equal to $(T_2\times A_2)\div T_3$, where T_2 equals the old number of two-phase turns per coil, A_2 the area in circ. mils of the old two-phase conductor, and T_3 the new, three-phase turns per coil. In this case the new size of wire equals $(23\times 3{,}257)\div 19=3{,}942$ circ. mils. The nearest size to this is No. 14 with 4,107 circ. mils. Checking for slot room, $23\times 3{,}257=74{,}911$ circ. mils, and $19\times 4{,}107=78{,}033$ circ. mils. Then, $78{,}033-74{,}911=3{,}122$ circ. mils, which is less than one No. 15 wire per coil or two No. 15 wires per slot. Thus 19 turns of one No. 14 s.c.e. wire will be the more satisfactory to use.



This shows the new three-phase, 220-volt, six-pole, winding, connected two-parallel star.

This motor was originally wound for two-phase operation. In the new winding there are 18 coil groups, numbered from 1 to 18; the number of coils in each group is indicated by the figures in the circles. The coil leads are also designated by figures to show the order of connection.

The three-phase, 220-volt, six-pole, 1,200-r.p.m., 5-hp., winding data are, 48 coils, each wound with 19 turns of one No. 14 s.c.e. wire, pitch 1-and-8, connected two-parallel star, 18 groups, or 12 groups of three and six groups of two coils per group, connected as shown in the accompanying diagram.

Wilkinsburg, Pa. A. C. ROE.

Correcting Usual Troubles With Insulating Varnishes

MOST of the difficulties encountered with insulating varnishes are due to failure to understand troubles which come as the result of not knowing what will happen under various conditions in the use of such varnishes. Some of the more common troubles are discussed in a bulletin on insulating varnishes and compounds recently issued by the Sherwin-Williams Co., Cleveland, Ohio. The more important sections are as follows:

Curdling or separation of different components of the varnish may be due to a number of causes among which are adding thinner while the varnish or thinner is too cold, adding the thinner too rapidly and not stirring it in thoroughly, allowing the cover of the dipping tanks to remain open, thus causing the varnish to partially oxidize, or using a thinner which is deficient in solvent properties. It is most important that a good quality benzine be used as many of the benzines now on the market are mixtures of light and heavy oils and are not good solvents.

Black spirit varnishes, when shipped in tin cans, sometimes thicken up after the can has been opened. This is due to a chemical reaction which takes place between the dye in the varnish and the iron of the can, as most commercial tinplate is imperfectly coated with tin.

When varnish is applied by dipping, metal tanks should not be used. Wooden tanks or tubes are best.

Low dielectric strength is generally due to the varnish not being thoroughly hardened. The remedy for this is obvious.

Corrosion of the copper wires is due in every case to the varnish not being thoroughly oxidized. Oil-type varnishes contain vegetable drying oils and these oils are compounds of glycerin and various fatty acids. In the combined state these oils are neutral, and after they have been combined with oxygen in the process of drying, they are changed into entirely different substances which have no acid character whatever. However, if a long-oil varnish is applied to a coil and then not completely oxidized, the unoxidized oil will, after a time, under the action of the heat which is present in all electrical apparatus, decompose into glycerin and free fatty acids and it is these free fatty acids which cause corrosion.

The remedy lies in the method of using the varnish. Reduce the thick-

ness of coating or increase the baking time until the varnish is thoroughly dried. Make sure that the coils are not draining in such manner that the varnish collects in pockets. If these measures fail to correct the trouble, the only alternative is to use a shorter oil, quicker baking varnish which can be thoroughly dried in the length of time permissible.

Softening of enameled wire is due entirely to the manner in which the varnish is used. Benzine is the mildest solvent available for making varnishes. Turpentine and coal-tar distillates are much stronger solvents and if used in an insulating varnish will attack the enamel on enameled wire. Under certain conditions, a benzine-solvent varnish may affect the enamel. If the coils after dipping are placed immediately in the oven and the baking started at a high temperature, the benzine will be boiled.

As is generally known, the solvent properties of any solvent are greatly increased by heating. Also, the heat tends to soften the enamel and make it more readily affected by the benzine and while at the lower temperature benzine has no effect, at the higher temperature the combined softening and solvent effect may injure the enamel. There is also a possibility that the high heat may rapidly oxidize the varnish on the surface and form a film which will prevent the escape of all the solvent underneath. The enamel would then be subjected to the action of this solvent throughout the entire baking period.

The remedy for this trouble is to allow plenty of time for draining and to start the baking at a low temperature and continue at this temperature until all the benzine has evaporated. The temperature can then be adjusted to the regular baking temperature. A baking temperature of not over 85 deg. C. is recommended for the first two hours of baking.

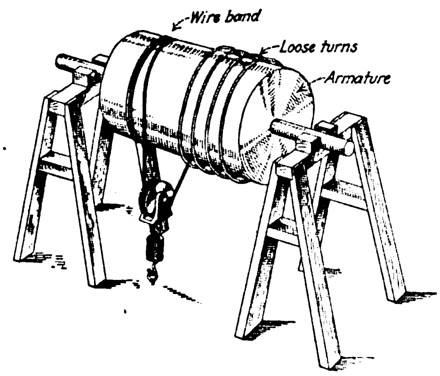
Method of Banding Armature When Power Is Not Available

IN AN article on page 453 of the September, 1925, issue of INDUSTRIAL ENGINEER, Maurice M. Clement described how an armature was banded which was too large for handling in a lathe. This brings to mind a method that can be used where neither a lathe nor any other machine suitable for this type of work is available.

As shown in the illustration, the armature to be banded is placed between two ordinary saw-horses or other suitable supports. One end of the banding wire is fastened on a part of the core between any two band spaces. Then sufficient wire for banding is wound loosely on the armature, allowing a few extra turns. The end of the wire is brought through a single block pulley suspended underneath the armature, as shown, and back around the armature, starting the first band in the usual manner.

A spring attached to the floor, as shown in the illustration, a weight hung directly on the block, or a combination of lever and weight may be used to give the desired tension on the wire.

By this method of banding, the power required to turn the armature



With the armature mounted on suitable supports, enough wire for banding is wound on loosely. After starting the band, tension is put on the wire by means of a spring or weight.

is only that needed to overcome friction. The weight or spring always keeps the wire under tension and the armature can be stopped and left in any position without blocking it to keep it from turning. Further, no adjustment of the wire tension is required, as it will always be constant.

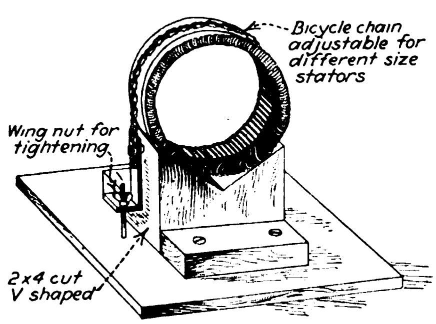
Philadelphia, Pa. HOWARD DAVIES.

Easily Constructed Support for Small Stators

IT IS oftentimes difficult to hold small stators while an old winding is being replaced or repaired. Consequently, the stator support illustrated in the diagram will be found very useful.

To make this, a 2-in. by 4-in. block of wood is cut V-shaped and fastened by wood screws to a suitable flat surface or bench. For additional support two strips of wood are fastened down alongside the front of the block on the 4-in. side. An old piece of chain, preferably bicycle chain because of its flexibility, is used to hold the stator which rests in the V-shaped groove.

One end of this chain is fastened to a wood screw located on the narrow side of the 2-in. x 4-in. wood block. By hooking the chain over this wood screw, the head of which is filed off on opposite sides in order to slip through the links, quick adjustability can be obtained for any length of chain required. An L-shaped iron strip is securely fastened by means of a small bolt to the other end of the chain. A wing-nut and bolt which passes through the lower end of the L-shaped piece serves to tighten the chain, so as to hold the stator firmly while working on it.



This support for small stators can be readily adjusted to fit different sizes of stator frames.

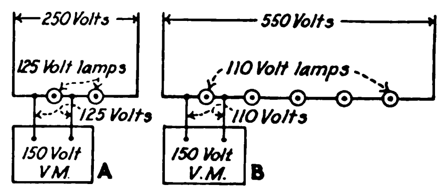
Different sizes of stators may be handled by first adjusting the chain to approximately the desired length, by slipping it over the wood screw at the proper point, and then tightening the wing nut.

Kincaid Electric Shop, J. P. KINCAID.
Durant, Okla.

How to Check Voltages Higher Than Capacity of Voltmeter

OCCASIONS arise in testing or repair work where it is necessary to measure voltages that are higher than the capacity of any available voltmeter. A simple method of overcoming this difficulty is to place lamps of known voltage in series across the line to be tested.

In a series circuit the voltage drop across each lamp is the same, providing the lamps are of equal resistance and size. A check by placing the voltmeter terminals across each lamp will readily prove this. The readings should be the same and, of course, the number of lamps in series times the voltmeter reading will equal the voltage across the line.



Voltages higher than the capacity of the voltmeter may be measured by placing a sufficient number of lamps in series across the line and taking the voltage drop across the terminals of one lamp.

The voltage of the circuit will then be equal to the voltage drop across one lamp times the number of lamps in series.

The voltage and number of lamps to be used will depend on the voltage of the supply. In the diagram, *A* shows how the voltage of a 250-volt circuit may be checked by putting two 125-volt lamps in series across it and reading the voltage drop across the terminals of one of the lamps. A 550-volt circuit may be checked in the same way by using five 110-volt lamps in series, as shown in *B*.

This method will be found very satisfactory where great accuracy is not required, and will make it unnecessary to buy additional voltmeters which would be used only for occasional testing. If several lamps are connected in series, tested to make sure that they are well matched and retained for testing purposes, the trouble of connecting them up each time will be eliminated.

Philadelphia, Pa. HOWARD DAVIES.

Convenient Testing Equipment for Fuses and Lamps

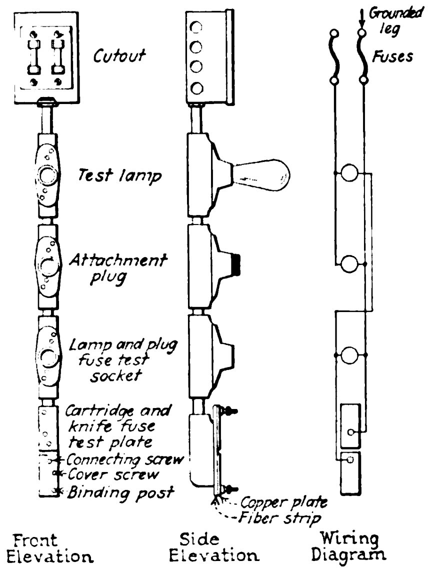
IN MANY small industrial plants the only available equipment in the maintenance shop for testing fuses and lamps to see if they are burned out, or for detecting shorts or grounds on equipment, is a convenient cutout and the electrician's old stand-by, the weatherproof socket spliced to a piece of lamp cord. Even in plants that have excellent facilities for testing large motors, testing in the shop of fuses or lamps from stock is done with the above-mentioned makeshift connections.

Both time and money are wasted when valuable equipment and operators stand idle, because general maintenance men, lamp cleaners or operators have replaced blown fuses or burned-out lamps with bad fuses or lamps from the department stock. Then the electrician is sent for to repair supposedly defective equipment, while men and machines stand idle. Such delays can be prevented if testing facilities are available for those whose duty it is, to replace blown fuses or broken lamps.

For this reason in one plant I made up some inexpensive testing outfits of conduit fittings, like the one illustrated in the drawing. It was so convenient to use that it prevented untested lamps or fuses from being used for replacement. The lamp and plug fuse testing socket was made by removing the shell of a receptacle and hammering the threads flat, using a piece of ½-in. pipe for an anvil. The lamp or fuse could then be pushed into the socket without being screwed in. This eliminated labor on the part of the person using it and encouraged its use. By substituting a brass disk about ¾ in. in diameter for the spring contact in the base of the receptacle, and raising this disk by placing fibre washers under it so as to make the socket shallow, single-contact bayonet-base lamps used in automobiles and candlelabra-base lamps used as indicating lamps could also be tested.

The test plate for cartridge and knife fuses is made by securing two copper or brass plates to a piece of ¼-in. fibre about 6 in. long and separating the two plates about ⅛ in. Care must be taken to countersink the heads of the cover screws so that they will not come in contact with the plates and cause a short-circuit across the device. Fuses ranging in size from instrument type to those of 200-amp. rating can be tested by placing them across the plate. Larger, or high-voltage, fuses can be tested by placing a screwdriver or any handy piece of metal on one of the plates and touching it to the fuse end. Double-contact, bayonet-base lamps can also be tested on the plate. By placing binding posts on the ends of the test plates, leads may be taken off for testing for shorts or grounds when repairing small apparatus at the bench. Ordinary test leads that are permanently fastened at one end have a very short life, as every electrician knows, and usually when one is in a hurry to use them they are broken. By the use of these binding posts any scrap wire around the shop can be quickly attached to make an improvised pair of test leads whenever occasion demands or for an emergency.

By using a 50-or 60-watt lamp as a test lamp, all types of lamps can be tested from a 2 c.p. auto-lamp to a 200-watt lamp. There will be no danger of burning out the small, low-voltage lamps when they are tested on 110 volts in series with the test lamp. The larger lamps, of course, will burn only very dimly when in the test socket. In wiring be sure to bring the hot leg to the test lamp and the grounded leg to the testing devices, to prevent accidental shorts from grounds.



Here is a testing outfit that is made of standard conduit fittings and will facilitate the testing of lamps, fuses and other equipment.

The material required and the cost of this testing device is as follows:

Material	Cost
1 3-in. by ½-in. by 5-in. cutout box	$0.35
1 2-wire, 30-amp. cartridge fuse cutout	.40
2 15-amp. cartridge fuses	.30
3 Type C conduit fittings, ½ in.	1.11
1 Type E conduit fitting ½ in.	.27
3 Conduit fitting receptacles	.81
4 ½-in. by 2-in. nipples	.20
1 ½-in. locknut	.01
1 ½-in. bushing	.02
8 ft. No. 14 R. C. wire	.06
For Test Plate	
1 piece of fibre ¼ in. by 1¼ in. by 6 in.	.06
2 pieces of copper ⅛ in. by 1¼ in. by 3 in.	.20
2 1-in., 8/32—F. H. brass screws	.02
2 8/32-in. brass battery nuts	.02
2 ¾-in., 6/32 F. H. brass screws	.02
2 ½-in., 6/32 F. H. brass screws	.02
2 6/32 hex. brass nuts	.02
2 ⅛-in. brass washers	.01
For Test Receptacle	
1 fibre washer ⅜ in. by 1 in.	.05
1 brass disk 1/16 in. by ¾ in.	.02
1 6/32 F. H. brass screw (length will vary according to make of receptacle used)	.01
	$3.98

The amount of labor necessary for assembling the above at the bench will be one man for 1½ to 2 hr. The amount of labor for installing the testing device will depend upon how far a line must be run to the place where it is being installed.

WM. H. FREDERICKSON.
Elizabeth, N. J.

Inexpensive Clamp for Holding Commutator Together

IT IS frequently necessary to remove a commutator from an armature and keep the copper bars and mica segments in their proper position while repairs are being made, or so that the commutator can be sent to the manufacturer as a sample. In the latter case it is particularly advisable to keep the commutator intact, to indicate the proper diameter; otherwise the new bars and segments may not fit together properly.

Many methods of holding a commutator together are used, but most of them are unsatisfactory. In some shops it is the practice to wrap a piece of copper wire around the bars and twist the wire as tightly as possible. In other shops the bars are wrapped with several layers of friction tape. A third method is to place the armature in a lathe and band the segments carefully with armature banding wire, which is then soldered. This last method cannot be improved upon if the commutator is to be used only as a sample. I offer the following method as being practical and inexpensive, with the added feature of permitting the bars to be tested for electrical defects and repaired.

All mill supply houses sell hanger iron, which is steel strip about ⅛ in. thick and 1 in. wide, with ¼-in. round holes punched at 1-in. intervals. This material is used for supporting steam and water pipes.

A handy commutator clamp may easily be made by cutting off a piece of hanger iron of suitable length with a hacksaw and bending ½ in. or so of each end at a right angle. The strip is then formed around the commutator and a small bolt put through the ends to tighten it. Any kind of thin strip iron could, of course, be used, but when hanger iron is used it is not necessary to drill holes for the holding bolt, which saves time.

The circumference of the commutator may be measured with a piece of twine. Experience will soon show how much to allow for the bends at the ends of the strip. When tightened the ends should be separated about ⅜ in. A steel bolt 1½ or 2 in. long, which fits loosely in the holes in the strip and is heavy enough to stand considerable strain, should be used. A bolt of this length may be loosened to remove a bar for repairs and tightened when the bar is replaced, which will also tighten the commutator. When removing a commutator bar it is well to wedge the opening with a piece of wood or metal, so that in case the workman is called away no one can tamper with the loose segments and thus wreck the whole commutator.

For small commutators one can purchase adjustable clamps, such as are used on the hose connections of automobile radiators, from any accessory store for a few cents each.

If a piece of heavy paper is placed between the steel clamp and the commutator the latter may be tested for short-circuits between the bars.

Cleveland Heights, Ohio C. B. KECK.

New Equipment

for plant operation and maintenance

Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these new devices which are designed to improve plant operation or reduce operating and maintenance costs.

New Electric Space Heater

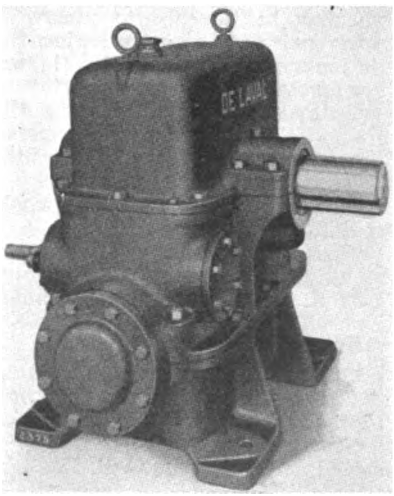
THE Chromalox line of electric heating units manufactured by Edwin L. Wiegand Co., 422 First Ave., Pittsburgh, Pa., has been increased by the addition of a space heater. This unit, it is stated, was developed to meet the requirements of general air heating where low first cost is a deciding factor. A cross-section of this unit is shown in an accompanying illustration.

This unit has triple-spiral imbedded resistors and a large radiating surface area for general air heating.

These units are 2 ft. long with mounting holes 22¾ in., center to center, and are made in 500-watt units for 110, 220 or 250 volts. If an increase in wattage is not a factor, these space heaters will operate, it is said, on higher voltages.

Worm Reducing Gears for Ratios Exceeding 100 to 1

WHEN using worm gears for ratios above 100 to 1, as required for driving cooling tables, conveyors, stokers, heat-treating furnaces, escalators, and so on, it is often desirable to use two steps, with which the highest reduction ratios ordinarily required are readily attained. The two-stage worm reduction gear illustrated herewith has been developed by the De Laval Steam Turbine Co., Trenton, N. J., for ratios up to 8,000 to 1. The one casing carries all bearings for the high-speed worm shaft, the low-speed worm shaft, which also carries the high-speed wheel, and the low-speed wheel shaft, thereby insuring accurate alignment and perfect meshing. There are only three working members, excluding the ball bearings of the two worm shafts, and these parts are heavy and rugged. End thrust and bending strains from the driving and driven machines are avoided by the use of flexible couplings.



The one-piece casing also acts as an oil reservoir. A positive oil pump draws oil from the reservoir and forces it through passages to the low-speed shaft bearings. Escape of oil along the high-speed worm shaft is prevented by a packed gland, while the seepage of oil along the low-speed shaft is avoided by the use of an oil slinger working between the end of the bearing and an oil guard surrounding the shaft and held in grooves in the casing and cover.

New Thermaload Starter

IN THE new thermaload starter made by the Monitor Controller Co., Baltimore, Md., the thermal expansion units are of thermal metal and it is stated that no liquid of any kind is employed. These expansion units are helically wound, fixed at one end and pivoted, but free to turn at the other end. Actuating arms attached to the free ends of the expansion units transmit their motion to the contact arm of the relay. Movement of this arm under overload conditions opens the relay contacts and breaks the circuit for the holding magnet of the main line contactor. This causes the main line contactor to open and disconnect the motor from the line. It is claimed that an ingenious arrangement of two contacts on the relay, insures flutter-proof operation.

The thermal or heating units of various ratings are interchangeable, thus enabling a starter to be changed from one horsepower rating to another by inserting the proper thermal units. This permits motors to be changed or shifted about without shifting around or changing starters and without disturbing the wiring.

The starter is manufactured in two types. One type has a self-resetting thermal relay and is used with three-wire, momentary-contact control circuits. The second type has the relay arranged for manual reset and may be used with either two-wire maintained-contact or three-wire momentary-contact, pilot-circuit control. The three-wire momentary-contact master stations have the start circuit normally open and the stop circuit normally closed.

Support for 600-Volt Buses

A NEW support for potential and synchronizing buses for 600 volts or less has been announced by the General Electric Co., Schenectady, N. Y. It is said to be made of non-fragile material and is designed to withstand tight clamping.

This support will hold three $\frac{5}{16}$-in. bus tubes and, with the addition of spacers, will hold three additional tubes. It is furnished with insulating tubes for holding copper tubing but is also adaptable to the use of copper tubing insulated with circular loom.

Automatic Time Switch

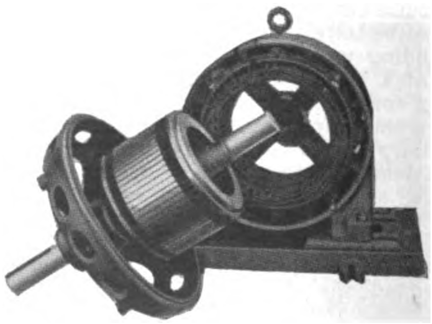
THE Eureka time switch for automatically turning on or off electrical connections, is announced by the Eureka Tool & Machine Co., 42 Walnut St., Newark, N. J. This switch is mounted with a clock on the base of a box, 4⅝ in. by 6½ in. by 3 in., and may be set to operate at any time desired.

Some of the industrial uses are: starting of electric furnaces; controlling heating of lead or other metal melting pots; operation of signs and battery chargers; control of other heating or power equipment which operates on a time schedule. One common use, it is stated, is for turning on heating devices in the morning, so that they will be hot by the time the men commence work, and automatically turning them off again at night to prevent fire from overheating.

Automatic, Self-Starting, Induction Motor

THE Type AA Ideal induction motor is announced by the Ideal Electric & Manufacturing Co., Mansfield, Ohio. It is stated that this motor which is shown in an accompanying illustration, accomplishes magnetically what heretofore has been done by mechanical means. The construction and principle of operation are described by the manufacturer as follows:

The Ideal automatic, self-starting, induction motor is a squirrel-cage induction motor with a double squirrel-cage winding in the rotor. The outer squirrel-cage winding in the top of the rotor slots has about ten times the re-



sistance of the second squirrel-cage winding in the bottom of the slots and during the starting period, furnishes high starting torque with low inrush of current from the line. At the start the frequency of the rotor current is the same as the stator or line current, but gradually becomes less as the rotor begins to revolve and become zero at synchronism or full speed. Since the low-resistance winding is imbedded deeply in the rotor iron, it has high reactance at the start and therefore low current. The outer, high-resistance winding, which is near the surface, has low reactance at the start and, therefore, higher current. As the rotor gains speed the reactance of the inner squirrel-cage winding decreases until at full-load speed it operates like a standard squirrel-cage winding. Because of the great difference in resistances of the two windings, the high-resistance winding carries very little current at full-load speed. Thus the transition or change-over from the starting to the running condition is accomplished magnetically, or simply by a change in the reactance of the rotor.

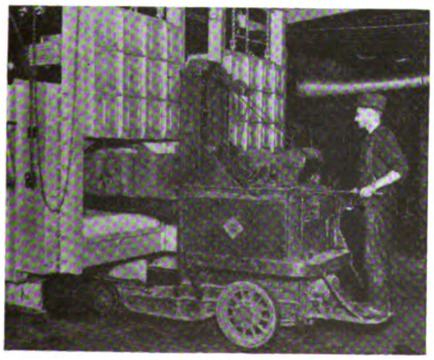
The manufacturer states that this motor can be started on full-line voltage without the use of a compensator or other current-limiting device. Also, it is said that the starting torque is from 135 per cent to 175 per cent of full-load running torque with full-line voltage impressed on the motor terminals.

Type AA motors are built in any size from 3 hp. to 100 hp., or larger if desired.

Furnace Charging Tructor

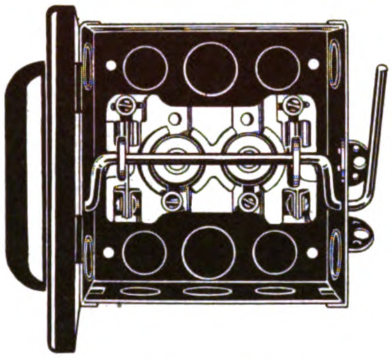
THE success attained in treating heavy pieces of alloy steel has brought a demand for better facilities for handling the output. To keep apace, Elwell-Parker Electric Co., Cleveland, Ohio, has developed a new type of portable, battery-driven furnace charger. This unit is propelled by an Elwell-Parker electric motor and is steered on all four rubber-tired wheels. The drivers are 22 in. by 4½ in. while the trail or smaller wheels beneath the load-supporting forks carry dual-differentiating 10 in. by 6 in. tires.

The load supports consist of two 92-in. by 8-in. horizontal fingers upon which ten 300-lb. packed furnace boxes are placed. The bottom of the furnace is provided with two slots to receive the lower flanges of the fingers. The furnace floor between and at each side of the slots supports the boxes or pots when the fingers are lowered and withdrawn. The furnace is set above the floor to provide clearance for the smaller axle thrust beneath the furnace when charging or discharging. The fingers are secured to two steel arms which are provided with hardened rollers on ball bearings. These rollers travel on renewable ways attached to 8-in. upright channels. The lifts are from 11 to 72 in. high as required.



Two-Pole, Plug-Fuse Switch

THE new Type 33, 30-amp., 125-volt, two-pole, plug-fuse entrance switch, Class B, is announced by The Wadsworth Electric Mfg. Company, Covington, Ky. This switch, which is shown in an accompanying illustration,



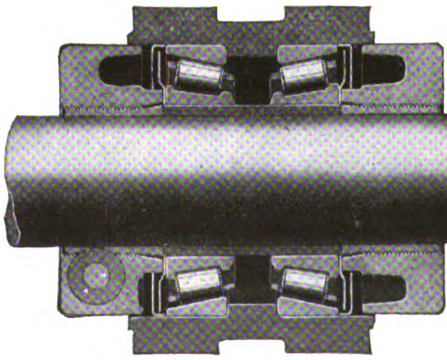
is provided with knockouts in removable end plates at the top and bottom, and in the sides and back of the cabinet. This switch, it is stated, is particularly adapted for small motors, heavy-duty lighting or industrial heating circuits, and many other industrial applications within the capacity of the device.

Roller-Bearing Loose Pulley

FURTHER application of Timken roller bearings to power transmission equipment has been announced by the Dodge Manufacturing Corp., Mishawaka, Ind., in the new Dodge-Timken roller bearing loose pulleys which are now available in both iron and steel. It is said that the problem of lubrication which is always a feature of great importance in loose pulley operation, has been given special attention. In addition, a positive dustproof feature has been provided.

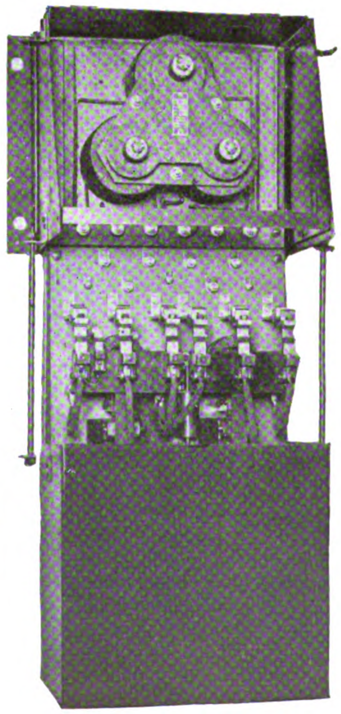
The steel loose pulley consists of an Oneida steel pulley provided with an extra large bore to accommodate a Dodge-Timken roller bearing unit mounting. The pulley is not split, but is riveted at the rim; the clamp hub holds the unit mounting in place. The cast-iron loose pulleys are made from regular, double-belt, solid iron pulley patterns and for diameters up to and including 20 in. the pulleys are counterbored to receive the Dodge-Timken unit mounting which is the same as that used in the steel pulley, except that the hub of the pulley serves as the housing. In diameters over 20 in. the pulleys are bored straight to receive the unit mounting, which is secured by setscrews.

The Dodge-Timken unit mounting consists of two Timken tapered roller bearings mounted on a ground steel tube and fitted to an accurately machined cast-iron housing. Grease seals and two clamping collars are mounted on the threaded ends of the steel tube. The tube is slotted and threaded at each end and is held to the shaft by the two collars which are used to obtain accurate adjustment of the bearings on the steel tube. A cross-section of a pulley hub is shown in an accompanying illustration. It is stated that the special grease seals positively prevent dust working in or lubricant working out. In both steel and iron pulleys a lubricating feed pipe is located between the arms, so as to be conveniently accessible, and is inserted through a hole bored in the pulley hub.



New Impedance Starter for Squirrel-Cage Motors

AN entirely new design of squirrel-cage motor starter that obtains reduced voltage for starting by means of impedance coils in series with the motor primary, instead of the more usual primary resistors or auto-transformers, has been developed and placed on the market by the Rowan Controller Company of Baltimore, Md.



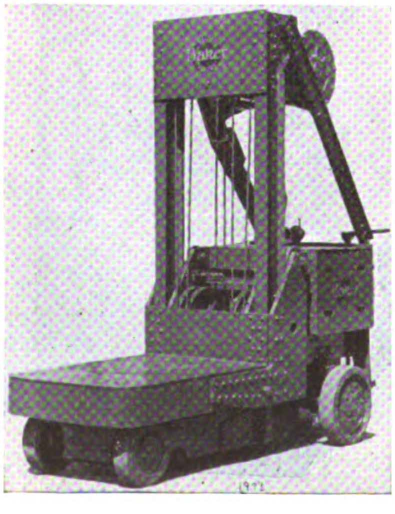
In brief, this starter consists of two sets of contactors that are immersed in oil, three impedance coils which reduce the line voltage, and a start-stop push button switch. Upon pushing the start button, one set of contactors closes and starts the motor on reduced voltage; the closing of the second or running contactor is controlled by the action of a dashpot and the voltage across the motor terminals, which automatically increases as the motor speed increases. It is said that this combination will always start the motor and vary the time of acceleration according to the amount of load on the motor so that the line disturbance will be a minimum.

For protection against overloads, single-phasing, and short-circuits, either a circuit breaker or a combination thermal and instantaneous overload relay panel is provided. The latter will give thermal protection against running overloads or single-phasing, and instantaneous overload protection in case of short-circuits or heavy grounds. In the illustration on page 101 the oil tank has been dropped so as to display the contactors for inspection. Likewise, the cover, hinged to the top of the controller, has been removed to allow inspection of the impedance coils. The starter is said to be practically dust-tight when closed.

Six-Ton High-Lift Truck

THE accompanying illustration shows the new Baker 6-Ton Hy-Lift Truck, being marketed by the Baker-Raulang Co., Cleveland, Ohio. For several years men in the steel stamping and automotive industries have recognized the high-lift type of industrial truck as the most practical machine for changing dies conveniently and at low cost. Naturally, these heavy loads have proven rather destructive to trucks designed to carry 2- or 3-ton loads, but this 6-ton machine has been designed of heavy construction.

The power is obtained from a Baker totally-enclosed series motor driving through a worm reduction and full-floating axle shafts. The hoist is of the two-cable type and the drums are driven by a compound-wound motor through a combination worm and planetary reduction.



Automatic Time Switch

A POSITIVE-ACTING, completely automatic time switch of Swiss manufacture but made to conform to conditions in this country has been placed on the market by The States Co., Hartford, Conn., under its own trade name. These motor-driven switches are said to be applicable to all possible combinations of control or selective switching. The driving motor used with these switches consists, primarily, of a two-pole armature which is arranged to oscillate freely in a constant magnetic field produced by a steel permanent magnet.

The time dials in general are divided into hours and fractions of hours and turn one revolution during twenty-four hours. For comparatively heavy current (75 amp. to 200 amp.) and voltages up to 3,300 a time and cut-out oil switch of the quick-break type is available. The clock movement and driving motor, similar to that described above, are contained in the upper part of the switch in a cast-iron case that may be sealed. The oil container is suspended by four rods, with a screw thread their entire length, coupled together by a linked chain.

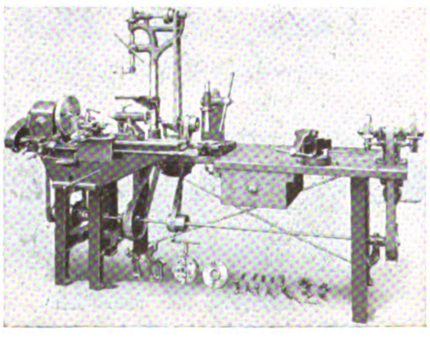
This company is also furnishing an electrical temperature regulating apparatus, which uses one of its time switches in connection with its "Thermo Regulator."

Combination Metalworking Unit

A WORK BENCH on which a lathe, drill press, arbor press, vise and grinder head are conveniently arranged, as shown in an accompanying illustration, has been brought out by the Artisan Manufacturing Co., 839 W. Sixth St., Cincinnati, Ohio. This combination unit, which has the trade name of Artisan Metalworker, is especially designed to meet the needs of the small repair shop, electrical department, or the maintenance department in industries which do not have a metal-working department.

As shown, the various tools are mounted on a hardwood bench top, 7 ft. by 2 ft. 6 in., which is supported on cast-iron legs. The tools are driven from a countershaft extending lengthwise under the bench. This countershaft may be driven either by a ½-hp. motor or may be belted to a lineshaft. The lathe has 11 in. swing over the bed, 16 in. swing over the gap and takes 24 in. between centers; standard lathe tools are furnished with the outfit.

The grinder is equipped with two 6-in. by 1-in. emery wheels which are driven from a flanged pulley on the countershaft. When the grinder is not in use the belt hangs slack but when needed, a double pulley idler is thrown in, thus tightening the belt which drives the wheel.

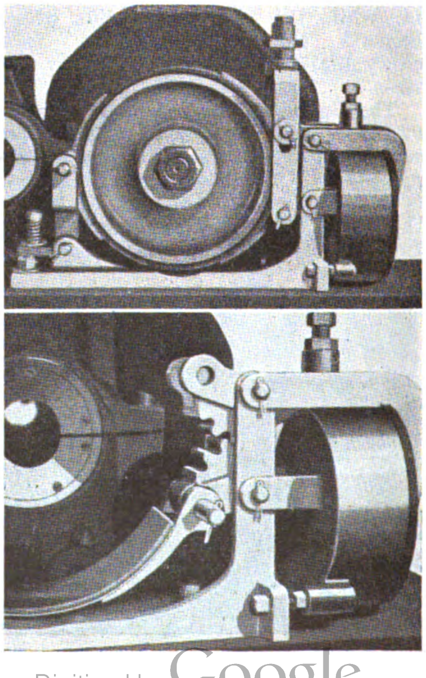


Electrically-Operated Brake

A NEW type of brake for use on electric cranes, elevator motors, electric hoists, motor-driven screw-downs, and similar applications is now being manufactured by the Clark Controller Co., Cleveland, Ohio.

The general appearance of the brake is shown by the top picture in the accompanying illustration, from which it may be noted that the friction band acting upon the brake wheel is divided into two parts, which are duplicates. It is stated that about 89 per cent of the brake wheel surface is utilized for braking. The cylindrical device at the right contains a spring and a magnet for setting and releasing the brake. The action of these two devices is transmitted through the bell crank, which is mounted above the cylindrical device and is pivoted to the frame, as shown in the bottom illustration. This bell crank operates the two geared sectors, shown in detail in the bottom illustration, which in turn tighten or release the friction bands around the brake wheel. The brake is said to be equally efficient in either direction of rotation of the brake wheel.

There are two adjustments, one for the braking torque, and the other to compensate for the wear of the brake lining. Both of these adjustments are easily accessible. The same general design of brake is adaptable for alternating-current operation and also for use as a foot-operated brake.



Practical Books

for your personal library

Every man who aspires to larger responsibilities should build up a professional library containing carefully selected volumes on subjects related to his work. Copies of the books which are reviewed here may be obtained from the publishers mentioned.

Electricity and the Structure of Matter—By L. Southerns, Lecturer in Physics, University of Sheffield. Published by Oxford University Press, London, England, 120 pages, illustrated. Price $1.50 net.

This is one of the series of "The World's Manuals," a group of introductory volumes designed not only for students, but also for the great body of general readers who are sufficiently alive to the value of reading to welcome authoritative and scholarly work presented to them in terms of human nature. About 30 pages are devoted to a historical discussion of the subject up to the discovery of the electron. The remainder of the book covers some of the lesser understood applications of electricity. A glossary of technical and uncommon terms which are used in this volume is included.

* * * *

Rewinding Small Motors—By Daniel H. Braymer, formerly Editorial Director, INDUSTRIAL ENGINEER, and A. C. Roe, Industrial and Insulation Engineer, Renewal Parts Engineering Dept., Westinghouse Electric & Mfg. Co. Published by McGraw-Hill Book Co., Inc., 370 Seventh Ave., New York, N. Y., 240 pages, illustrated. Price $2.50.

Readers of INDUSTRIAL ENGINEER need no further introduction to these authors. Much of the information in this book has appeared in early issues of INDUSTRIAL ENGINEER; it has, however, been rearranged in this volume and much material added for the purpose of making it as useful as possible to practical men either with a greater or less amount of experience.

The authors have compiled in this volume practical information on winding procedure for fractional horsepower, direct- and alternating-current motors. This discussion includes all the common types of windings used for portable drills, grinders, automobile starting motors, sewing machine motors, desk and ceiling fans, vacuum cleaner and washing machine motors, and other similar applications of these small units.

The information has been presented in step-by-step details from the start to the finish of a winding job so as to make it easy for the experienced winder to understand the procedure and give him a grasp of the essential requirements of the windings that are used by the manufacturers of small motors and so enable him to rewind or change them as conditions require, even though he may not have had much experience in the rewinding of small motors. The practical side of the winding operation has been dealt with in detail, giving as little technical information as is required to understand the reasons for the winding procedure that is presented. This is intended to be a practical man's handbook on the subject, although it will be found to be a useful reference book as well.

* * * *

Health Maintenance in Industries—By J. D. Hackett, formerly Manager, Medical Department, Nichols Copper Co. Published by A. W. Shaw Co., Chicago, Ill., 477 pages, illustrated with tables and charts. Price $5.

The object of this book is to show those who manage plants how the workers' health may be maintained and improved as a means of increasing production. The subject is treated simply and its medical and surgical aspects are dealt with only in so far as may be necessary to their understanding from the plant manager's point of view.

Considerable attention is given to plant hygiene and plant sanitation. Entire chapters are devoted to the following subjects: Ventilation, heat and heating, plant lighting, food and lunch rooms, fatigue removal, rest periods and seating, toilet facilities and sanitary standards, washrooms and washing facilities, lockers and locker rooms, laundry and cleaning, drinking water, occupational dusts and diseases.

* * * *

Electrical Machinery Erection — By Terrell Croft, Consulting Engineer. Published by McGraw-Hill Book Co., Inc., 370 Seventh Ave., New York, N. Y., 306 pages, illustrated. Price $3.

The practical methods and processes used in modern practice in the mechanical installation of electrical machinery, from the unloading of the apparatus from the car to its final fixing and aligning in its ultimate operating location, are discussed in this book. Some of the subjects included are: unloading and moving, supporting, erecting, locating, and fixing electrical machinery. A section of the volume is devoted to the mechanical maintenance of electrical machinery, particular attention being paid to the bearings.

* * * *

Power Plant Lubrication—By William Farrand Osborne. Published by McGraw-Hill Book Co., Inc., 370 Seventh Ave., New York, N. Y., 262 pages, illustrated. Price $3.

The purpose of this book is to present, in such a way as to be of the greatest possible value and practical use, the principles of lubrication and the solution of lubricating problems which have been worked out by the author. It will be of value to everyone who is interested in the operation of machinery or the purchase of lubricants. Because the whole subject of lubrication is so broad and involves so many details, both as to theory and practice, the subject matter has been confined to the practical requirements of power plant machinery. However, with the general principles of lubrication of such machinery firmly in mind, the application of these principles to other types of machinery is comparatively simple.

Part I is devoted to a discussion of the physical and chemical properties of lubricants, their action under the changing influences of heat, pressure, and so on, and the methods of determining their relative magnitude and value. Part II covers the practical applications of lubricants to the principal types of machinery commonly found in power plants. Part III contains specifications of lubricants which have been found suitable for many types of service and are recommended to purchasers of lubricants who wish to buy in this manner. Standard methods of testing lubricants are also given.

* * * *

Light, Photometry and Illumination Engineering—By William E. Barrows, Professor of Electrical Engineering, University of Maine. Published by McGraw-Hill Book Co., Inc., 370 Seventh Ave., New York, N. Y., 400 pages, illustrated. Price $4.

This book has been designed as a text in illuminating engineering and as a reference work for the practical engineer. It is an outgrowth of the author's previous books, "Electrical Illuminating Engineering," and "Light, Photometry and Illumination." However, approximately two-thirds of this text is new.

It has been the aim of the author in this book to assemble the latest ideas and thoughts available on the subject of artificial illumination and the choice of lighting equipment. Much information on present practice will be found in the chapters on the different classes of lighting. Various types of lighting installations are discussed, and numerous charts, diagrams and tables, as well as illustrations, give the theoretical and practical sides of illumination.

* * * *

Coils and Magnet Wire—By Charles R. Underhill, Consulting Electrical Engineer. Published by McGraw-Hill Book Co., Inc., 370 Seventh Ave., New York, N. Y., 474 pages, illustrated. Price $4.

All power transmission lines begin and end in coils. The problems involved in the use of electrical conductors and electrical insulation are common to all forms of coils regardless of the use to which they may be applied. Therefore, in this volume, particular stress is placed on the conductor and the insulation. The subject of magnet wire is thoroughly treated, also. Much space is devoted to the composition and application of wire enamel and its properties as a film, as well as the usual cotton, silk, paper and asbestos coverings as applied to magnet wire.

Internal and external insulation of coils receive the consideration their importance deserves. Methods of designing various coils are described. Some of the conventional methods of winding and finishing coils are treated in a general way, and some in detail. Because the small details that are so easily overlooked are usually the causes of failure of coils, and therefore of the entire apparatus or machine of which such a defective coil is a part, considerable emphasis is placed throughout the text upon points that need watching.

Trade Literature

you should know about

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Electric Machinery Catechism—Bulletin H338 carrying the above title, presents in a simple way in a 36-page, question-and-answer discussion the most important theoretical and practical features of the common types of d.c. and a.c. motors, generators, and control equipment. Numerous charts and illustrations are used.—Fairbanks, Morse & Co., 900 S. Wabash Ave., Chicago, Ill.

Heating and Ventilating—Recent circulars show the use of the Ventura disk fan in connection with unit heaters and for ventilation of industrial plants.—American Blower Co., Detroit, Mich.

Grounding Devices—A number of loose-leaf sheets illustrate, describe, and price the various types of Groundulets for facilitating the making of ground connections wherever necessary.—Groundulet Co., 86 Park Place, Newark, N. J.

Arc Welder—A 24-page bulletin discusses arc welding and gives the particular advantages claimed for the Lincoln Stable-Arc welder. Various units are illustrated and described.—The Lincoln Electric Co., Cleveland, Ohio.

Battery Charger—Bulletin 6561 describes a line of individual and multiple motor-generator sets for battery charging.—The Hertner Electric Co., W. 113th St., Cleveland, Ohio.

Roller and Ball Bearings—Bulletins describe the line of Hoffmann Precision roller and ball bearings, and single- and double-ball thrust bearings, for heavy loads and hard service. Several pages are devoted to a discussion of the lubrication and instructions for mounting.—Norma-Hoffmann Bearings Corp., Stamford, Conn.

Mica Undercutters—Circulars describe the No. 6 type of Hullhorst mica undercutting machine and disk type of mica cutter.—The Hullhorst Micro Tool Co., Dept. 2, Toledo, Ohio.

Pipe Threading—A circular describes the No. 4 Beaver power-driven, pipe-threading tool which will handle from ¼-in. to 2-in. pipe and, when used with a special universal shaft and Beaver die stocks, pipe up to 6 in. in diameter.—The Borden Co., Warren, Ohio.

Screw Pumps—A circular describes Quimby screw pumps which are used for handling various heavy liquids and semi-liquids, such as oils, tar, molasses, soap, and so on, at high pressure.—William E. Quimby, Inc., Parkhurst St., Newark, N. J.

Bus Supports—A series of bulletins describe various types of bus supports and disconnecting switches.—Electrical Development & Machine Co., Holmesburg Junction, Philadelphia, Pa.

Wall Chart—A 17-in. by 25-in. wall chart contains a number of useful and practical tables, such as, a copper wire chart, allowable carrying capacities of copper wire and cables, common insulating materials, decimal equivalents, drill sizes, condensed tables of trigonometric functions, and other tables. This will be mailed to any user of insulating material when requested on his business letterhead.—Mitchell-Rand Mfg. Co., 18 Vesey St., New York City.

Light Globe Removers—A circular describes four different types of portable apparatus for charging electric light globes in places difficult of access.—Pierpoint Mfg. Co., Lock Box 195, Pana, Ill.

Grinders, Buffers and Polishers—Catalog 825 describes the line of C. A. W. motor-driven grinders, buffers and polishers. These have a double head, with the motor mounted in the head, and Timken adjustable, taper roller bearings.—Cleveland Armature Works, 4732 St. Clair Ave., Cleveland, Ohio.

Electric Trucks—A circular describes the line of Wright-Hibbard power-operated, elevating-platform trucks which are especially built for narrow passages and short-radius curves.—Wright-Hibbard Industrial Electric Truck Co., Inc., Phelps, New York.

Automatic Electric Control—Circulars describe the No. 848 Mercoid Control, industrial type, which is used to automatically open or close an electric service circuit, feeding motors of 1 hp. or less, upon a change in temperature, pressure, or vacuum.—The Federal Gauge Co., 564 W. Adams St., Chicago.

Wire Stripper—A circular describes the Acme electric cord and wire stripper, a hand tool which can be set for various sizes of wire.—A. Laubscher, 77 Fort Pleasant Ave., Springfield, Mass.

Threadless Conduit Fittings—A booklet entitled, "A Message for You of Economic Importance," illustrates a number of the special Knodu-Box threadless conduit fittings, shows how they are applied and gives some interesting figures concerning the cost of installation of threaded and threadless conduit fittings.—Erie Malleable Iron Co., Kondu Division, Erie, Pa.

Splices and Tapes—A 14-page booklet describes various tapes and other insulating materials and explains and illustrates in detail how to make a splice on rubber-insulated wire.—The Okonite Co., Passaic, N. J.

Industrial Ovens—A circular describes the Type I Freas electric industrial oven, thermostatically controlled, for industrial baking, drying and other uses.—The Thermo Electric Instrument Co., 8 Johnson St., Newark, N. J.

Lighting and Other Electrical Products—Catalog 24 covers the complete line of Benjamin electrical products. Sections of especial interest to industrial plant men are: Industrial illumination data, reflector brackets, various lines of lighting equipment, industrial signals, heavy-duty, water-tight wiring devices, and others.—Benjamin Electric Mfg. Co., 120-128 So. Sangamon St., Chicago, Ill.

Flexible Coupling—A circular shows the construction of the Falk-Bibby flexible coupling and gives some examples of its use under heavy service. These couplings are made in capacities ranging from 1/3 to 20,000 hp. at 100 r.p.m. rating.—The Falk Corp., Milwaukee, Wis.

Electric Heat in Industry—A 32-page illustrated bulletin, GEA-261, carrying the above title, deals with the advantages of electric heat for various industrial applications, including the metal industry, heat-treating, ceramic industry, chemical industry, printing industry, finishing processes, and other such uses.—General Electric Co., Schenectady, N. Y.

Pyrometers—A 56-page catalog, Part-4000, describes and illustrates the complete line of Tycos pyrometers and charts. Several pages are devoted to a discussion of the selection of a pyrometer, principles of operation, application, method of installing the thermocouple, maintenance, testing and engineering data.—Taylor Instrument Co., Rochester, N. Y.

Speed Reducers—A circular describes a line of Herringbone continuous-tooth speed reducers which are made up to 150-hp. capacity and in reduction ratios up to 250 to 1.—Foote Bros. Gear & Machine Co., 236-246 N. Curtis St., Chicago, Ill.

Motor Fuse Rating Card—A convenient card for posting up, tabulates the full-load current, indicates the correct rating of starting and running fuses for properly protecting different types and sizes of motors, and gives other information.—Chicago Fuse Mfg. Co., 1511 W. 15th St., Chicago, Ill.

Conveying Machinery—A 24-page monthly bulletin entitled "The Labor Saver" is devoted to descriptions of installations of labor-saving conveying machinery and of new units of conveying and elevating machinery as they are developed.—Stephens-Adamson Mfg. Co., Aurora, Ill.

Dust Collectors—Bulletin S-125 illustrates a number of Sly dust arresters in different industries and shows their construction and operation.—The W. W. Sly Mfg. Co., Cleveland, Ohio.

Safety Switch—Circular describes the Super-Safety electric switch in various types and capacities.—Super-Safety Switch Co., 1219 W. 103rd Pl., Chicago.

Non-Metallic Gears—A 26-page bulletin describes several installations of Celeron non-metallic gears operating under severe service conditions and gives considerable information on turning and cutting these gears.—Diamond State Fibre Co., Bridgeport, Pa.

Insulation Resistance Testing—A circular describes the Cory-Record Ohmmeter which is used for testing the insulation resistance of electrical apparatus or cables.—Chas. Cory & Sons, Inc., 183-7 Varick St., New York City.

Motion and Operation Recorders—Catalog 1600 describes the Bristol mechanical and electrical motion recorders which automatically record the actual operation, the time of operation, and the extent of mechanical movement of machinery, elevators and hoists, conveyors, opening and closing of doors, gate valves, and so on.—The Bristol Co., Waterbury, Conn.

INDUSTRIAL ENGINEER

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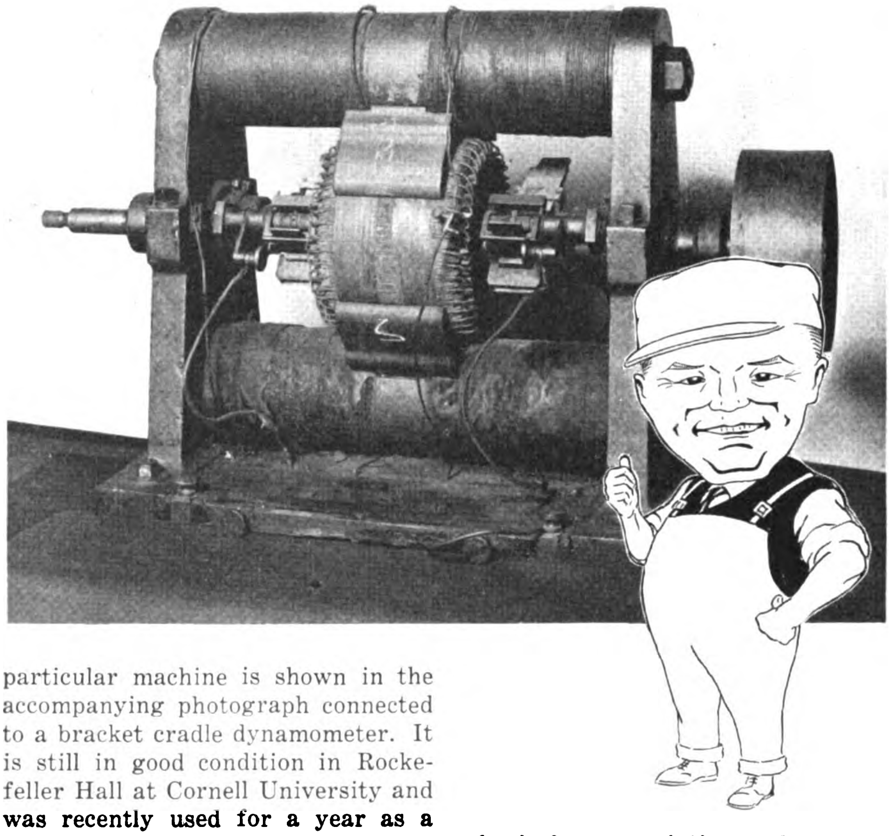
A Generator of 50 Years Ago—

and one of a very few of the first designs now available for inspection



IN THESE days of continual improvements and refinements in equipment, those of us who are 40 years of age or better either forget or do not stop to realize that all of our present electrical equipment has had its birth in crude forms during the past 50 years. We are all moving so lively these days and demand such accuracy and reliability that unless we take the time to bury ourselves in musty records now and then, there is a tendency to become blind to the service a dollar will buy today when spent for motors and generators, for instance.

Just to go back in point of time to 1875, when Thomas A. Edison was working on an unheard-of machine for generating current at constant potential, we find that there was interesting work being done on an experimental basis at other points here and abroad and one of these was the laboratories at Cornell University. Here Wm. A. Anthony, and George S. Moler, professors in the Department of Physics, were constructing a "dynamo-electric" machine, so-called in distinction from earlier "magneto-electric" machines. This was a Gramme machine similar in the main to the original Gramme design built in France, but with some added features including movable rocker arms for the brushholders. It was also provided with two sets of armature windings, each with its own commutator which could be used independently or connected in parallel or in series. This particular machine is shown in the accompanying photograph connected to a bracket cradle dynamometer. It is still in good condition in Rockefeller Hall at Cornell University and was recently used for a year as a shop motor.

From a construction standpoint it is of interest to note that this machine was originally wound with square wire, but this was later replaced with round wire, the cotton insulation being put on by hand. This generator, huge in size as we now know generators of like capacity, delivered 20 amp. at 150 volts with the two armature windings connected in series. It was exhibited at the Centennial Exposition in Philadelphia in 1876, at Chicago in 1893, and at St. Louis in 1904.

This particular machine is of interest today because it is available for inspection by those interested and is strictly typical of the first thinking of designers of electric generators. Moreover, it serves as a basis for appreciating and comparing the wonderful development work in electrical design that has taken place in this country in the short space of 50 years. Today a plant without a single motor is an oddity and one with a thousand or more creates little comment, for such a number of motors often requires less attention and supervision than an equivalent number of other mechanical devices.

If you are 30 years old today put this item carefully away for 25 years and it will then be a valued treasure, if you are still interested in electrical work.

Practical Pete

The synchronous motor is the accepted type of motor drive for most large ammonia compressors. This illustration shows four Electric Machinery Co. synchronous motors coupled direct to as many compressors. Manual control, as shown by the switchboard in the right background, is used for controlling these motors. The small motor-generator sets at the right furnish the excitation for the motors.

Factors to consider when selecting

Power Drive Equipment for Ammonia Compressors

including type and capacity of motor required, kind of control apparatus necessary, and the type of mechanical connection that should be used for coupling the motor to the compressor

By GORDON FOX
Electrical Engineer, Freyn Engineering Company, Chicago, Ill.

SINCE the advent of raw water ice the electric motor has been extensively adopted for driving ammonia compressors for ice manufacture. The cost of ice made by electric power is usually materially less than that made by steam or oil power. The labor is reduced. The location of the ice plant is independent of the fuel supply. The first cost of the plant is lower, and it is superior in general convenience.

Cold storage warehouses and packing houses are also large users of ammonia compressors for refrigeration, the majority of these being motor driven. Smaller installations for miscellaneous refrigerating uses are very numerous.

Refrigerating and ice plant loads are attractive to public utilities. They are steady loads of considerable magnitude, often on a 24-hr. basis. In some instances arrangements can be made to shut down for a few hours during the daily peak. The summer demand is normally heavier than the winter demand. Because of the desirable character of these loads, favorable rates are usually available.

In an ammonia refrigerating system the ammonia is drawn into the compressor and raised to a pressure of approximately 150 lb. per sq. in. The compressed gas then passes to the condenser, where the temperature is reduced below the boiling point of ammonia corresponding to the high pressure. The compressed gas, therefore, becomes a liquid. The liquid ammonia then passes to a receiver, where it is stored. From this receiver the liquid goes to the expansion coils. Upon reduction of pressure it again passes into the gaseous form, absorbing heat from its surroundings in so doing. The gas then returns again to the compressor and repeats the cycle.

Characteristics of Compressors Affecting Motor Selection

The ammonia compressor is similar in general characteristics to the air compressor. Much of the discussion relating to air compressors, which was given in the article on page 13 of the January, 1926, issue of INDUSTRIAL ENGINEER, is equally applicable to ammonia compressors. The following discussion will, therefore, be confined largely to those aspects wherein the ammonia compressor differs somewhat from the air compressor.

Ammonia compressors may be either single-stage or two-stage ma-

chines. Two-stage compression offers some advantage in higher volumetric efficiency, particularly for high-compression ratios, as during summer conditions. It reduces the loss due to "inlet heating" or expansion of the charge upon contact with the warm cylinder walls. It reduces the duty on the valves. It renders possible inter-stage cooling. However, usual water temperatures permit only partial cooling between stages. Ammonia must be used if it is desired to cool to the initial temperature. In the latter case some liquefaction occurs. The reduction in power consumption through the use of two-stage compression may range from 3 to 10 per cent, being materially less than for air compressors.

Ammonia compressors may be either single-acting or double-acting and are commonly built with one to four cylinders. Many of the larger units are of duplex design with the cylinders either vertical or horizontal, and the crank set at 90 deg.

Many ammonia compressors, particularly those of older design, employ poppet valves. The speeds of such units are particularly restricted. High-speed compressors are in reality short-stroke compressors, having higher r.p.m. but no higher piston speed. High-speed compressors have low valve lifts and commonly use plate valves. Because of the low lifts, either more or larger valves must be used than are required for slow-speed machines. Small valve areas lead to waste of power. Some of the large ammonia compressors operate at speeds as low at 72 r.p.m. From this point the different types range in speed up to about 240 r.p.m. It is desirable, from the viewpoint of both motor and flywheel, that speeds be as high as possible.

An air compressor works between approximately constant fixed pressures. The intake and discharge pressures of an ammonia compressor are subject to variation. The intake temperature and pressure are governed by the refrigeration load, and the discharge pressure is governed by the temperature of the condenser water, which determines the pressure necessary to cause liquefaction.

SELECTION of motors and auxiliary equipment for industrial applications is the subject of this series of articles by Gordon Fox. The first article of this series appeared in the January issue and discussed the application of power drive equipment to air compressors. The accompanying article supplements that discussion and shows the additional factors that must be considered in applying motors to ammonia compressors. In succeeding issues will be discussed the application of motors to other industrial equipment.

The commercial unit of refrigeration or "ton of refrigeration" is the heat required to melt 1 ton of ice. This equals 288,000 B.t.u. The expression commonly refers to the extraction of this amount of heat in a period of 24 hr.

The ice-making capacity is materially less than the refrigerating capacity. The exact value depends upon the initial temperature of the water, the final temperature of the ice and the amount of extraneous heat absorbed in process. Ordinarily from 1.8 to 2 tons of refrigeration are required to produce 1 ton of raw water ice.

POWER REQUIREMENTS OF AMMONIA COMPRESSORS

The compressor displacement required for a rated ton of refrigeration depends on the intake and discharge pressures. Ammonia compressors are commonly rated at standard conditions corresponding to an intake pressure of 15.67 lb. gage and discharge pressure of 185 lb. gage. For refrigerating duty to maintain freezing temperatures an intake pressure of about 5 lb. gage is generally maintained. For brine circulation or for ice making the intake pressure is from 15 to 20 lb. gage.

For conditions differing from rating, the capacity of a given compressor differs materially from its capacity under standard conditions. The variation of capacity with differing conditions is indicated in the table on this page. The capacity increases as the intake pressure increases in the same manner that the capacity of an air compressor increases with reduction of altitude. The capacity decreases as the discharge or condenser pressure increases.

The indicated horsepower of an ammonia compressor per ton of refrigerating capacity under standard conditions is about 1.4 to 1.5 hp.

Variation of Ammonia Compressor Capacity and Power Requirements for Different Intake and Condenser Pressures and Temperatures

Condenser Pressure and Temperature		Intake Pressures in Lb. Gage and Intake Temperatures in Deg. F.																	
		5 Lb.—17.5 Deg.			10 Lb.—8.5 Deg.			15.67 Lb.—0 Deg.			20 Lb.—5.7 Deg.			25 Lb.—11.5 Deg.			30 Lb.—16.8 Deg.		
Lb. Gage	Deg. F.	Capacity	Unit Power	Resultant Power	Capacity	Unit Power	Resultant Power	Capacity	Unit Power	Resultant Power	Capacity	Unit Power	Resultant Power	Capacity	Unit Power	Resultant Power	Capacity	Unit Power	Resultant Power
145	82	0.66	1.11	0.74	0.85	0.94	0.80	1.07	0.80	0.86	1.24	0.71	0.88	1.44	0.63	0.91	1.63	0.56	0.92
165	89	0.64	1.23	0.79	0.83	1.04	0.87	1.03	0.90	0.93	1.20	0.80	0.97	1.34	0.72	1.00	1.58	0.65	1.02
185	95.5	0.62	1.34	0.84	0.80	1.15	0.92	1.00	1.00	1.00	1.16	0.89	1.04	1.35	0.80	1.08	1.53	0.73	1.11
205	101.4	0.60	1.47	0.88	0.77	1.26	0.98	0.97	1.09	1.06	1.12	0.99	1.11	1.31	0.89	1.16	1.48	0.85	1.26

This table gives the ratio of refrigerating capacity, ratio of horsepower per ton of refrigeration, and ratio of resultant horsepower required, for different sets of operating conditions as compared with standard conditions of intake pressure of 15.67 lb., intake temperature of 0 deg. F., condenser pressure of 185 lb., and condenser temperature of 95.5 deg. F.

The columns marked CAPACITY give the ratio of refrigerating capacity of the ammonia compressor; the columns marked UNIT POWER give the ratio of horsepower required per ton of refrigeration; and the columns marked RESULTANT POWER give the ratio of resultant horsepower required by the compressor.

for single-acting compressors and 1.6 to 1.7 hp. for double-acting compressors. For conditions other than standard the horsepower per ton of refrigeration varies both because of the change in the amount of ammonia to be compressed and also because of the differing range of pressures between which the machine is working. As the intake pressure increases the amount of ammonia required per ton of refrigeration decreases and the horsepower per unit of value compressed also decreases. As the condenser pressure increases the amount of ammonia required per ton of refrigeration increases and the unit power also increases. The horsepower per unit of refrigeration is lowest with high intake pressures and low condenser pressures. Inasmuch as the capacity of a given compressor varies at the same time that the horsepower per unit of refrigeration varies, the resulting power requirement of the compressor depends upon both the capacity and the unit power consumption for each set of conditions and does not vary so widely, as will be seen from the accompanying table. A given ammonia compressor driven at a constant speed will take the least horsepower when operating with low intake pressure and low discharge pressure. It will take the most horsepower when operating with high intake pressure and high discharge pressure.

The graph on page 109 shows average values of indicated horsepower per ton of refrigeration at several intake pressures and over the range of discharge pressures.

The motor capacity should be about 125 per cent of the indicated horsepower for the larger machines and from 130 to 150 per cent for the smaller machines, rated at 10 tons or under, based on maximum load conditions with respect to the range of pressures to be expected. Unless otherwise stated it is customary to consider an intake pressure of 30 lb. and a discharge pressure of 215 lb. as representing the maximum load condition. As contrasted with the air compressor, which cannot be overloaded, the ammonia compressor may assume an abnormal load if the intake and discharge pressures become abnormally high. The motor is, therefore, subject to possible overloads.

The power required for ice making is subject to rather wide variation. Some plants operating at capacity under favorable conditions produce a ton of ice with 40 to 50 kw-hr., while the consumption may reach 80 to 90 kw.-hr. per ton. These figures are inclusive of auxiliaries. Many factors of design and operation may contribute to high power consumption. Among these may be mentioned insufficient condenser capacity, dirty condensers, non-condensible gases in the system, insufficient or warm condensing water, insufficient cooling coils, necessitating low inlet pressures, lack of proper heat insulation, leaky pistons, and insufficient ammonia charge. As the cost of power is a predominant factor in the cost of ice manufacture it is essential that conditions favorable to economy be maintained. The use of metered electric power is of great assistance to this end.

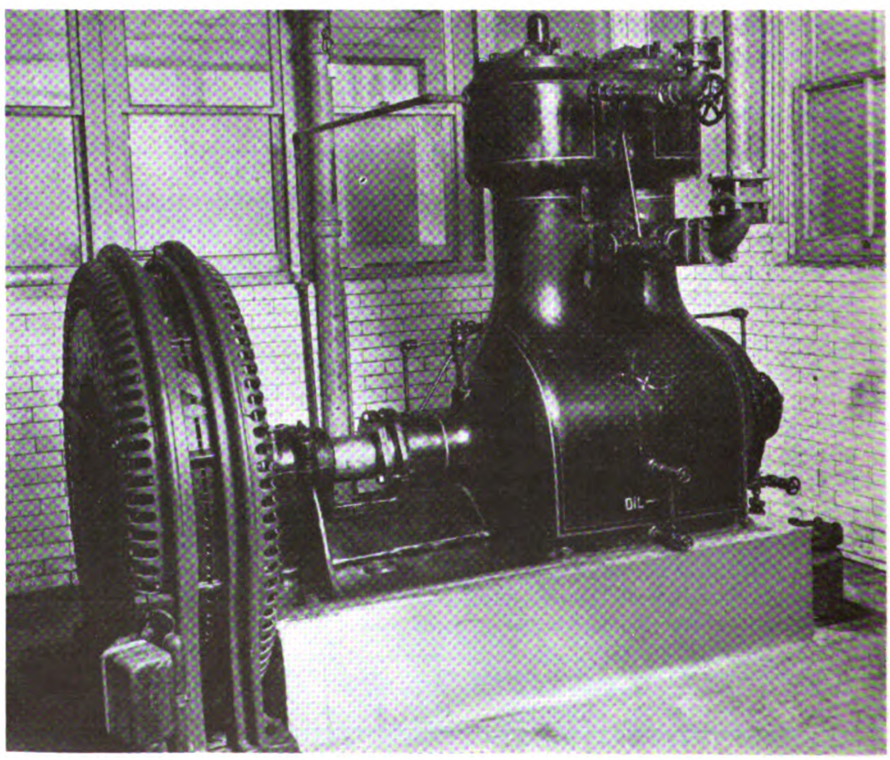
Methods of Varying Output of Ammonia Compressors

It will be observed from the table on page 107 that the capacity of a given ammonia compressor varies with changes of system conditions. In refrigerating service the amount of cooling effect required will vary. In ice manufacture it is also necessary to adjust the output to the demand. Several methods are in vogue to meet this need of variation of output. In many refrigerating plants, notably in the case of small and moderate-sized installations using direct-current motors, some form of speed adjustment is employed. In the larger refrigerating plants and in ice-making plants it is more common practice to install several compressor units, often of differing capacities, and to operate suitable combinations to meet the requirements, these units being driven at constant speed. In the case of duplex compressors it is sometimes the practice to disconnect one-half of the unit to halve the capacity. This practice is not desirable, from an electrical viewpoint, because of the greater torque pulsation, the requirement of greater flywheel effect and greater current pulsation. Some compressors provide for operation at partial capacities through use of variable clearance pockets. These permit reduction to about half capacity. They are hand operated. Ammonia compressors are not commonly provided with automatic and complete unloading devices corresponding to air compressor practice.

In general, the same types of motors are adapted to both air and ammonia compressors. Alternating-current drives predominate, but there are many direct-current drives also. The synchronous motor is the accepted type for most large

No motor bearings are required in this installation.

The rotor of this Electric Machinery Co. 75-hp., 180-r.p.m., synchronous motor is pressed directly on to the compressor crank shaft, the crank shaft bearings being large enough to carry the additional load. This does away with the necessity of an outboard bearing on the motor and makes the motor very accessible.



units, and for many of the smaller units. Its preference is dictated by the same advantages that apply to its application for driving air compressors. These motors are more commonly direct-connected. Induction motors are often used for driving ammonia compressors of small and medium size. This type of motor is not practical at very low speeds so that short-center belt, gear, or chain drives are employed to obtain the desired speed reduction. The wound-rotor induction motor is usually selected. This choice may be dictated by the desire to vary the speed or by the superior starting performance of the wound-rotor motor, or by both considerations. When the compressor is started unloaded, the squirrel-cage motor may be satisfactory in starting performance. The wound-rotor motor is inefficient at reduced speeds and is, therefore, open to objection. The brush-shifting type of polyphase commutator motor is well suited to the requirements of ammonia compressor service where speed adjustment is desired. This type of motor is also unavailable at compressor speeds so that direct connection to it is not possible. As this type of motor is relatively costly its selection must be justifiable on the basis of power economy in the event of extensive operation at reduced speeds.

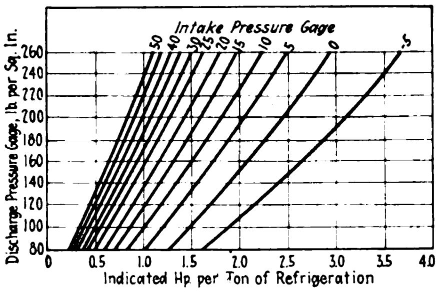
For some of the smaller automatic refrigerating equipments it is desirable that the motor be able to start the compressor without using a by-pass for unloading. The double squirrel-cage induction motor, connected directly across full voltage in starting, has been successfully applied to this service.

Where direct current is available the compound-wound motor is given preference for constant-speed service because of its superior starting performances and its better operation with fluctuating voltage. Many adjustable-speed, shunt motors are applied to compressors used for refrigerating duty. A speed ratio of 2 to 1 or thereabouts is common. These motors are commonly arranged for belt, gear, or chain drive, in which case standard motors may be utilized. However, special, slow-speed motors for direct connection are sometimes used.

One respect in which the ammonia compressor differs from the air compressor, from the motor application standpoint, is the occasional requirement of speed adjustment for refrigerating duty. This leads to the use of motors providing speed control, as contrasted with the almost universal use of constant-speed drives for air compressors.

Selection of Type of Drive Connection

In methods of mechanical connection to the motor the ammonia compressor parallels closely the air compressor. The smaller units are commonly chain or belt driven, the short-center belt drive with idler pulley being popular. This arrangement permits the use of standard, moderate speed motors. Belt and rope drives were originally employed with synchronous motors. Later it became the practice to couple a self-contained synchronous motor, provided with bedplate and pedestal bearings. This type of installation is shown in the illustration at top of page 106. It is now the prevailing practice to use engine-type motors having the rotor mounted directly on the compressor shaft. In some cases an outboard motor bearing is used but this may well be omitted as shown in the illustration on page 108. In the case of duplex compressors the motor is commonly located between the halves, sufficient space being provided to permit the stator to be shifted to afford access to the windings. Some motors of this type are built with the rotor split in halves, the rims being clamped together with shrink links and the hubs bolted together during erection. This practice avoids the necessity of pressing the rotor on the shaft at either the compressor factory or the motor factory.



The power requirements of ammonia compressors vary with the intake and discharge pressures.

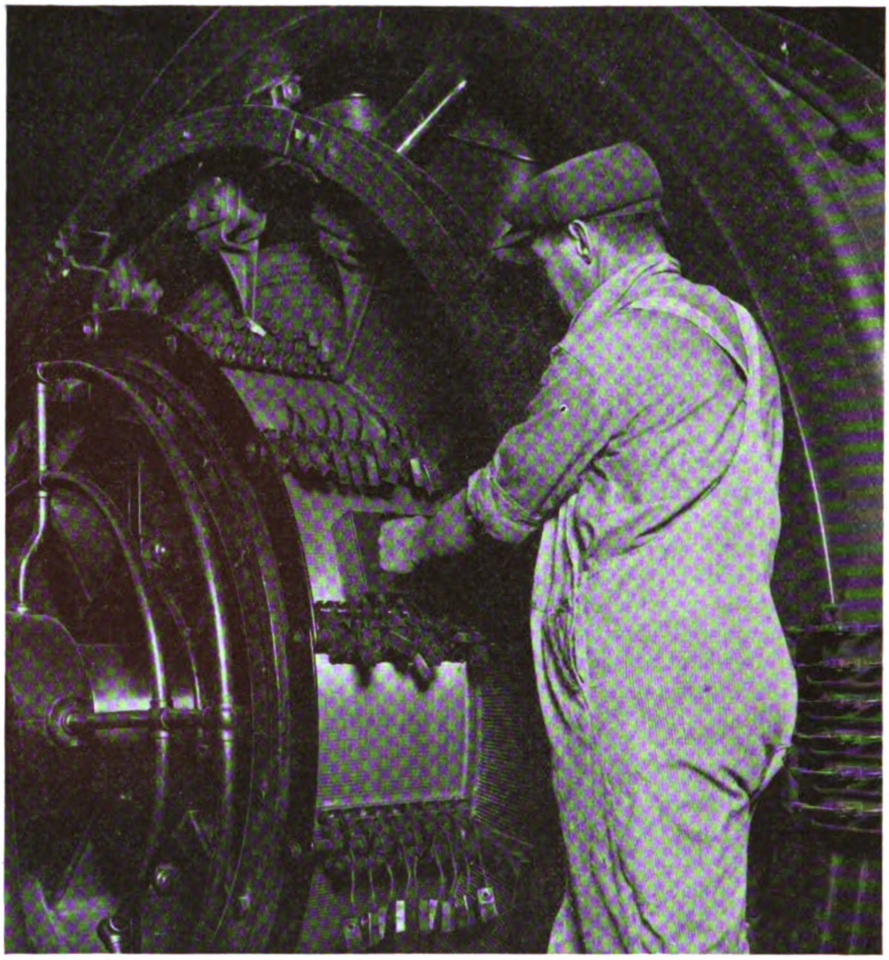
Each curve is for a different intake pressure. Follow the curve of the given intake pressure until it intersects the abscissa or horizontal line representing the given discharge pressure, then read down to the bottom scale to obtain the indicated horsepower per ton of refrigeration when working between the given intake and discharge pressures.

In the case of direct-connected, synchronous-motor-driven units it is a common practice to incorporate the flywheel effect in the rotor of the motor. Due to the lower speeds of ammonia compressors, considerably more flywheel effect is required than for air compressors. The flywheel effect demanded increases very rapidly as the speed is reduced. Duplex, single-acting compressors require much more flywheel effect than duplex double-acting compressors to restrict the current fluctuation within the prescribed limits. If a duplex unit is to operate with one cylinder disconnected, and also when the cylinders of a duplex unit work on different systems with differing pressures, additional flywheel effect is required.

Some installations have been made in which two enclosed vertical type, self-contained compressors have been set with their shafts end to end, both units being driven by a single motor whose split rotor is clamped over the two shaft ends forming a coupling between units with cranks at 90 deg. This permits the use of a motor of twice the horsepower of a single compressor but having the same speed as the smaller motor for a single compressor would have. As contrasted with two separate units this arrangement gives the advantage of multiple cylinders having a smoother torque diagram, allowing use of a small flywheel and minimizing the current fluctuation when desired. The motor may be shifted and either compressor driven singly, but with increased fluctuation of current.

The starting duty is more severe with ammonia compressors than with air compressors. Ammonia compressors cannot be unloaded in the same manner as air compressors but the cylinders can be by-passed. Even with a liberal by-pass the unloading is not as complete as that of an air compressor. The by-pass is commonly hand controlled. If the by-pass connection is not liberal in size the starting load may be high. The slower-speed motors used for ammonia compressors naturally develop less starting and pull-in torques than those of equivalent horsepower used for driving air compressors. The larger flywheels increase the starting torque required and render it more difficult to develop sufficient pull-in torque. Both the starting torque and the pull-in torque of the great majority of modern ammonia compressors fall within the range of 15 to 35 per cent of full-load torque.

COMMUTATORS perform a very important function and must be given a certain amount of skilled attention in order to keep them in proper condition and avoid operating troubles that are expensive and annoying. In this article Mr. Weber describes some of the methods and devices which he used years ago in taking care of the commutators on early designs of generators and motors, and contrasts them with modern practices and equipment.



Reminiscences of an old-timer on

Development and Use of Commutator Stones

with pointers on how to employ them effectively to improve commutation and keep commutators in good condition

As related by
WILLIAM L. WEBER
Manager, Acme Abrasive Co., Chicago, Ill.
In an interview with
Practical Pete

IN THESE days of specialized equipment that is as nearly perfect as highly-skilled designers with years of experience behind them can make it, it is interesting to talk over old times with some one whose memory goes back to the days when all electrical equipment was new and its actions more or less of a mystery. The services of factory experts were not available within a few hours, as they are now, and there were few, if any, instruction books and precedents to follow when trouble developed. All that a fellow could do was use his wits and trust to luck that they would show him what to do, and how to do it.

A few days ago I had the pleasure of talking with the old friend whose name appears at the beginning of this article and who has been working with motors and generators and all kinds of electrical equipment since some of us were in our cradles —or before then. We discussed many things; finally the conversation turned to commutators and how to care for them—always an important and interesting subject.

"You know," he said, "that back in the 80's we thought that a commutator on a 500-light dynamo was something tremendously large. It is easy to imagine myself back in the first central station of the Chicago Edison Co., hopping about between two 10-in. belts, which were driven by the two flywheel pulleys of a high-speed engine and operated two Edison dynamos with gauze wire brushes. I well remember what terror seized me when those 'chocolate brown' commutators suddenly presented a ring of clean, raw copper, caused by the copper brushes starting to cut. How I rushed for a piece of sandpaper and nursed that ring by massaging the commutator with the sandpaper and with tallow or some other mysterious lotion in order to get it back again to that much desired 'chocolate brown'!

"When I left that job and commenced to work for the Thompson-Houston Electric Co., in Chicago, whose shops were where the Peoples Gas Building now stands, I was confronted with about the same commutator difficulties as I had with those multi-numbered and elevated polepiece dynamos which I had just left. You remember the Edison dynamos, with the high polepieces, the small-diameter armature, and the impressive-looking 'main switch' on the top of it, right over the brushes, don't you? Well, now my new pets were called the 'Type L. D.' Thompson-Houston machines and while their armatures were spherical and larger, and the frames were horizontal, still the chocolate brown on the commutator was just as difficult to maintain. Turning a commutator was a job, as it was about 10 in. in diameter and about 12 in. in width. The armature had to be removed from the dynamo and placed between centers in a lathe, and every time it had to be done it was easy to hear the Prophets advise that this business was 'hokum' and would not last long.

"There was one elderly man in that shop for whom I had a great deal of respect. He was familiarly called 'Archie Demond,' and only a few months ago passed on into the Great Beyond.

"One day I was sent out on a trouble job which turned out to be a scored commutator and after looking it over and returning to the shop for instructions, 'Archie' told me to get a piece of grindstone, run that dynamo and grind the commutator as smooth as I could until the chain gang could bring in the armature. I did so and, after a number of hours' work, produced a commutator surface that was fine and dandy. This achievement was looked upon as quite original until a man came from Lynn, Mass., and confided to us that we were doing nothing original at all. He had been doing this same thing for nearly a year."

"News travels faster than that, now," I said.

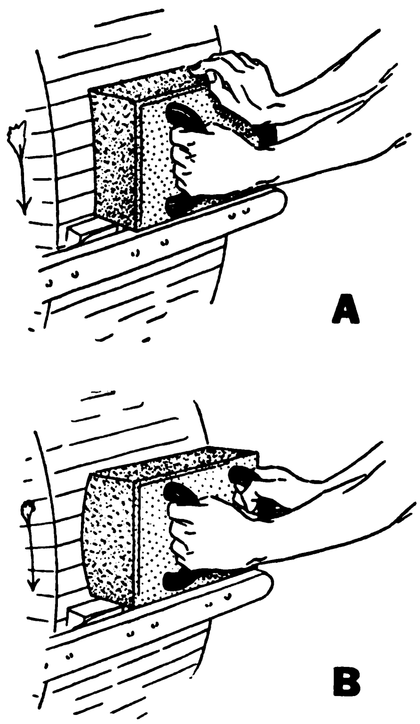
"Yes," he replied, "Can you imagine one branch of a company doing something for a year before the other branch of the same company hears of it—today?

"Something important happened about this time. A gauze wire brush with a few silver tubes running through it, was imported from Germany. The idea was that the silver tubes allowed air to pass through the brush to keep it cool, and at the same time afforded more rigidity than was obtainable in either the gauze or copper-leaf brush. It was represented that this brush would absolutely prevent cutting the commutator and retain that chocolate brown so much sought after. It did help some. Why, I do not know.

"Again something important happened. A Boston firm of grindstone quarrymen presented a natural stone, cut into a rectangular shape, to be used in place of sandpaper for grinding commutators. With this stone it was possible to grind about 1/32 in. off a commutator with an 8-in. face and the same diameter, in a day. It was looked upon as a great thing. Much was said about the special grit in this stone, and the particular kind of a stone it was, and the particular place where it was supposed to be deposited by the peculiar quip of Dame Nature.

"Then came another English product, supposed to be found in some 'Shire' on the other side. I had one of these in my tool kit and I remember that at one time I lost my watch and the commutator stone at about the same time, with the result that my grieving was directed entirely to the loss of the stone.

"As you know, commutation was not developed to its present-day degree of perfection until someone discovered a method of tapering off the abrupt magnetic break between the poles of a generator by interposing between the polepieces another set of magnets which were called interpoles. This was a great step toward sparkless commutation. It reduced the number of times we had to smooth up the commutator with either a stone, or a large wooden saddle with a leather cradle on which were bolted a number of layers of sandpaper; this was used by two men, one at each end of the device, pressing down on the commutator while it rotated. As one layer of the sandpaper became worn out it was torn off and the next, fresh layer came into play. Would you believe it, I actually saw this operation less than a year ago in a central station in a small town in New York!



This shows, A, the proper way to hold a commutator stone on the face of a commutator and, B, the wrong way.

If the stone is held by the handles, as in *B*, it will have a tendency to rock. As a result, the upper and lower edges of the stone will be rapidly worn away, producing a convex surface.

"Then came another step — the development of the graphite carbon brush. This was a real move because it actually lubricated the commutator while it was in service. Today there are many who still believe that with the graphite brush we have to maintain that 'chocolate' color, when in realty it is a glazed surface, which in itself is an imposed resistance between the brush and the commutator bar, and should not be there at all. The heat which we once tried to dissipate with the tubular German gauze brush is caused by the very same chocolate brown color. To demonstrate this to yourself, let that condition develop on the commutator of your automobile generator and it will quit generating. Another vivid demonstration is to remove the glaze on a d.c. generator commutator, without disturbing the field resistance setting, and note the voltage increase on the switchboard voltmeter. Note also that the commutator will operate at a lower temperature.

"To realize fully the importance of this, count the number of bars between brushes, multiply this by the r.p.m., and see how small a fraction of a second each bar is in contact with the brush.

"Some adventurous person thought that if natural sandstone would serve as a cutting stone for removing copper from commutator bars, why not use the harder, manufactured stone made of emery? It was tried, and with poor results, because in the first place the emery contained metallic particles and was itself a conductor of current; the small particles lodged between the bars, embedded themselves in the mica, and caused short-circuits. Besides, nothing along the lines of a satisfactory 'bond' with which to hold the particles together, had been developed.

"Some years later, in the production of aluminum, by melting bauxite clay in an electric furnace a sort of clinker was accidentally produced through some misadventure of the process; this clinker was looked upon as a most undesirable result of an otherwise good purpose. Later this clinker was found to be much harder than the emery that was being brought all the way from Turkey and, not only could it be controlled as to hardness and crystal form, but it was tougher and less of a conductor than the best emery mined. We now have various forms of this clinker crushed to different sizes of grains and known by numberless trade names, each variety having its own peculiarities.

"Wheels were made with various kinds and with various mixtures of the various kinds, bonded together with a thousand or more combinations of bonds. Among the more common bonds are shellac, silicate of soda, infusorial earths, and the like, fired in ovens at various temperatures and resulting in wheels of

different tensile strength for various speeds and for cutting numberless kinds of materials such as iron, steel, brass, copper, rubber, paper, etc. The numbers and letters found on a wheel, signifying the manufacturer's recipe for the particular mixture and process employed in making that wheel, are closely guarded as his business secret, and there are several millions of them. There is no business today with as little recorded information relative to it as the compounding and manufacture of grinding wheels, razor hones and the like.

"Several types of machines have been designed for grinding commutators with a grinding wheel while the commutator is rotating at its regular speed, with the idea of thus obtaining a surface that is as true as it is possible to obtain under working conditions, remembering the short period of time that each brush is in contact with each bar.

"It remained for someone to think of developing a manufactured grinding block which could be used in a stationary position for grinding the commutator face while it is turning at full speed, thus keeping the bars true after being finished. Taking advantage of the hard, sharp manufactured grain, and experimenting with a bond that would suit the purpose, have resulted in stones which are today capable of removing as much copper from the commutator face in 30 min. as could be done with a natural stone in a day, or more. Where a commutator has become ridged between brushes, or where flat spots have developed, it is now possible to resurface satisfactorily in much less time than required by turning and the final result is superior because the work is accomplished while under full speed."

"In your experience, what are some of the difficulties that users have encountered with commutator stones, and how can they overcome them?" I asked.

"Well," he answered, "objections have been registered by some plant operators to the effect that a commutator could not possibly be trued up with any of the several artificial stones, held to the face by hand. On the face of it this attitude seems reasonable, but when it is remembered that the process is, although old as stated, practically a new way to do the job, those who use a stone should consult someone who has had experience with it, before attempting to condemn it. Where flat spots have been developed it will be found that when using a commutator stone which has a sufficiently large face area, these spots will be 'bridged' because of the rigid nature of the stone, and only the high parts of the commutator will be ground off until sufficient copper is removed to permit the stone to reach the lowermost surface. The mistake has often been made of using a stone too small for the job, and thus really making the condition worse by grinding the flat spots more flat. Some manufacturers of these stones make them with the face of the stone concaved so that the low spots are not ground any deeper while the stone is wearing its grinding face to the curvature of the commutator.

"The surface speed at which the grinding is to be done has much to do with the coarseness or fineness of the stone used. A stone of this kind which seems to give good satisfaction at a speed of 5,000 linear ft. per min. would wear away faster at a linear speed of 1,000 ft. per min. The 'hogging cut' should be done with a coarse stone, and the 'finishing cut' with a fine one. If a certain cutting stone does nice work with comparatively low stone loss at a certain linear speed, and it wears away too fast at some other speed, or it 'clogs' copper at some other speed, the particular make of stone should not be condemned. To explain what I mean, I will mention the experience which many have had with a grinding wheel. A certain wheel is bought and placed in the grinder. It does the work splendidly. Later the wheel seems to have become 'soft' and wears away quite rapidly. If the r.p.m. of the wheel is increased to the point where the surface speed is the same as it was when new, it will again behave as it did at first. Now here is where the commutator stone manufacturer has his problem; he must produce a few different 'grades' which will serve over a wide range of speed. If the user of commutator stones has had trouble and will take the time to make a complaint and give the facts in the case to the manufacturer, the latter will, if responsible, immediately take back the stone complained of, and replace it with one that will do what is expected of it."

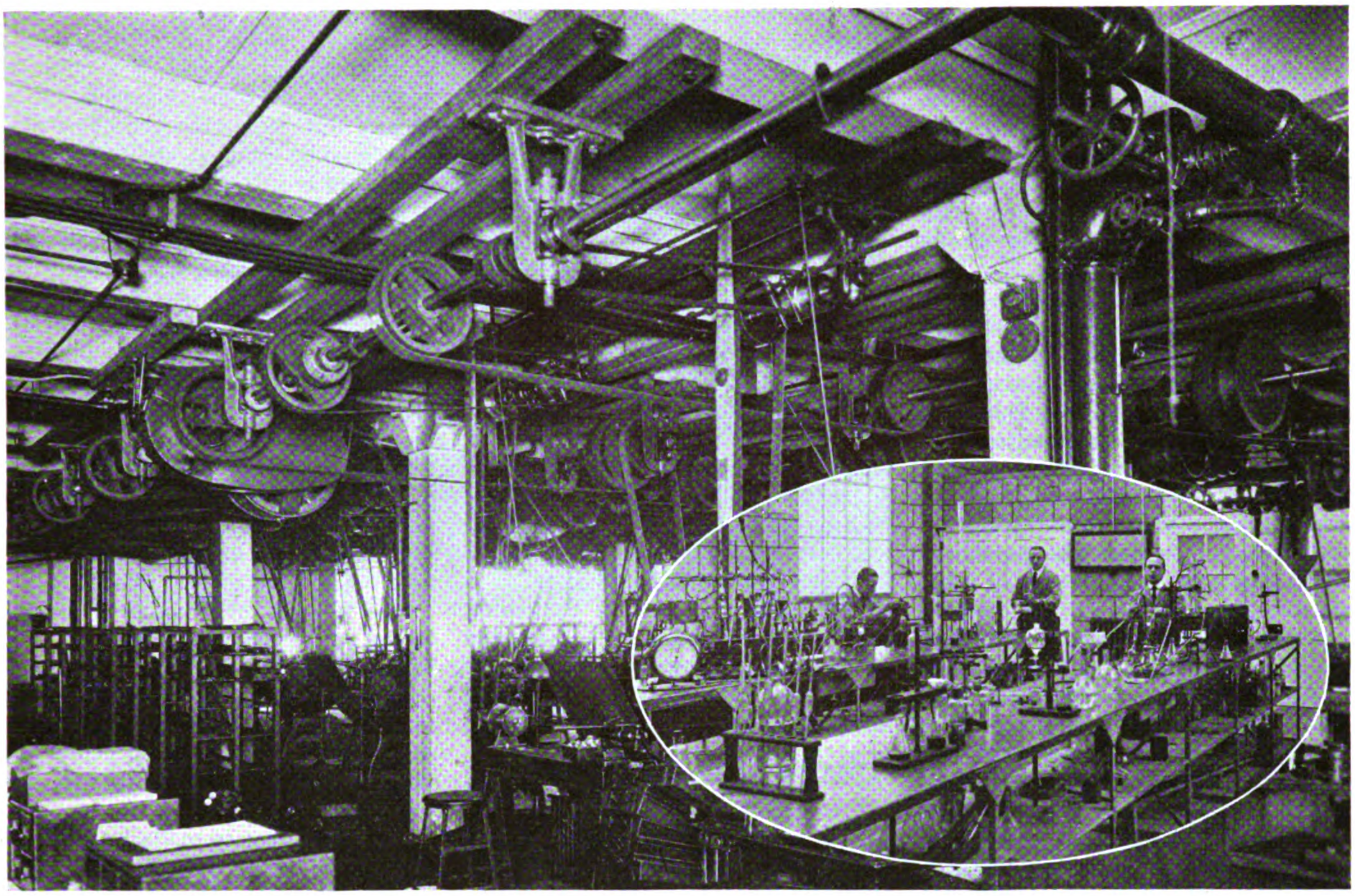
"What do you recommend should be done with a commutator that is out of round?" I asked.

"Where a commutator is worn elliptical or egg-shaped, it may be trued up with a stone by bolting a shelf rigidly to the brush rigging or frame on the down-running side of the machine; the shelf should be made of 2-in. plank and placed within 1/8 in. of the commutator. Now lay the stone on the shelf, hold it in position by hand, and allow the commutator to 'swipe' it at each revolution, moving the stone sidewise occasionally as a wood turner moves his chisel, only much slower. I have trued up commutators 8 ft. in diameter and 30 in. in width in this manner much more satisfactorily and a great deal quicker than could have been done by turning. After getting the commutator trued up, the finish grinding may be done free-handed.

"The manufacturer will advise what grades are required if the user will give the speed and size of the commutator and the width and clearance between brushes. Very small commutators are more easily removed and trued up in a lathe, but they may be maintained in good condition if a stone of medium grade is used in place of sandpaper; besides, the stone cost will be less than the cost of sandpaper. Collector rings, either of bronze, brass, iron or steel may readily be trued up with stones and the work is accomplished quite rapidly. The glassy, hard surface developed on collector rings can immediately be removed with any one of the several makes of stones.

"Here is something else that is worth considering from an efficiency standpoint; if the glaze is not allowed to form on a commutator and a high polish is maintained instead, the commutator and brush sets will operate much cooler. On a.c. motors of the slip-ring type, such as are used on elevators, if the glaze is replaced by a polish, the inrush of current will be reduced considerably and the time of acceleration also reduced, which results in a saving of current.

"Any of the various makes of so-called commutator stones should be kept well wrapped up when not in use, so that no oil or water will get on them. To look at them they do not seem to require any care in keeping, but many dollars' worth of them have been ruined by improper storage between the times they are used. They differ much from grinding wheels and the ordinary, so-called grinding blocks. Their production is the outcome of specialized study and their uses are many and varied."



Specifications for Oil and Grease Lubricants

The satisfactory solution of bearing problems in industry requires the use of a reliable lubricant.

Interruptions to service, which may be due to the failure of a bearing because of improper or inadequate lubrication, will cause far more loss than the cost of a lubricant selected for the work and its proper application. This industrial view was taken at the Addressograph Company, Chicago, Ill. The view of the laboratory and other illustrations in this article were supplied by the Vacuum Oil Co., New York, N. Y.

which includes a brief, non-technical discussion of the various characteristics that affect their application and lubricating value

By FRANK E. GOODING

Associate Editor, Industrial Engineer

TO THE average industrial operating man a discussion of the specifications and tests of lubricants leaves him with a smattering of statements and terms which he often understands vaguely. The purpose of this article is to clarify some of these ideas, explain the terminology, and indicate in a general way how the various qualities affect lubricating value.

The average industrial plant does not have the facilities for making oil tests. Plants with chemical laboratories under the direction of a trained chemist can make such tests, provided they buy or contain the special oil-testing apparatus which is required. Standard methods of making tests in this country follow the procedure specified by the American Society for Testing Materials and commonly called the A. S. T. M. tests. Specifications or results of tests can be made comparable only when based on the same standard procedure.

There are many characteristics of lubricants which might be described and many tests made to determine the nature and usefulness of lubricating oils. It is doubtful, however, if after making all these tests of an oil, the knowledge gained by an operating man would be very useful in determining the correct grade of lubricant to use for any given practical purpose.

One of the most important qualities of an oil, which determines its lubricating value, is its so-called "oiliness," or the ability to cling to a metallic surface. This quality is of great importance in that it assists in the retention of the oil within the bearing and also causes it to adhere to the rotating shaft firmly enough to be carried through between the shaft and its bearing. Without oiliness the pressure would squeeze the oil out from between the shaft and its bearing and leave a dry, metal-to-metal contact. Also, the oiliness of a lubricant affects the quality of retaining the oil on a stationary bearing so that it will not be dry when it starts up. Up to the present, however, there are no standard A. S. T. M. tests for determining oiliness. Many men attempt to estimate this quality of a lubricant by rubbing the oil between the thumb and finger. Even experienced lubricating engineers cannot rely upon the assumptions made

on the results of such crude tests.

In spite of the fact that tests do not always definitely determine the value of an oil for a given purpose, it would be well if everyone who has to do with the purchase and use of lubricants and lubricating oils knew what the more common tests are and what emphasis is to be placed on each.

For example, it is decidedly to the purchaser's interest when buying oil to know that in a great many instances such considerations as fire and flash tests of the oil he is buying are of very little consequence; that the specific gravity is not of vital importance; or that the color of the oil does not add to or detract from its lubricating value. The purchaser should know in a general way what these tests signify, so that he will not buy oil under the cloak of a technical barrage.

The *color* of lubricating oils, which are refined for many purposes, is given special attention only in the case of a very few lubricants. These lubricants may be confined to the "bleached" products which are repeatedly filtered for the purpose of providing a stainless product for use in textile work or similar industries where it might come in contact with the goods and cause damage. Generally, after an oil has been in use it picks up enough impurities so that the colorless qualities of the original oil are of little consequence. In the end, oil is purchased for use and not for looks. Color, however, does indicate to a certain extent the degree of refinement, neutralization and filtering. If an oil does not have a stable color after standing it may indicate that it is poorly refined. It may, on the other hand, indicate that the container was not clean when the oil was placed in it.

Although color is determined by the use of a tintometer by which the comparative color values are set down numerically, little or no importance can be given to these figures in determining the value and correctness of an oil for a purpose. In connection with the color of an oil, it is interesting to note, however, that the darker the oil the higher is the number denoting its color characteristics.

It is generally thought that the coloring matter in oil is nothing more than unsaturated hydrocarbons which are susceptible to decomposition under heat. Black oils or very dark oils naturally contain more of the unsaturated hydrocarbons than the filtered oils and are, therefore, not so capable of withstanding high temperatures and severe service as are the highly-refined and specially-treated oils.

All oils when subjected to heat, such as turbine oils or internal-combustion engine oils, oxidize more or less and immediately change to a darker color. This mere darkening of the oil must not be interpreted as a breaking down of the oil nor as a diminishing of its practical lubricating value.

Gravity Does Not Determine Lubricating Value

The *gravity* of an oil is another specification which is sometimes over-sold as to its relation to lubrication. The purchaser should always bear in mind that he is purchasing oils, not to match a set of figures denoting the physical characteristics of the oil, but for the service value of the oil. The gravity of the oil is something that is secondary and is usually a result rather than a predetermined factor. Refiners do not produce oil just for the purpose of displaying figures denoting its gravity.

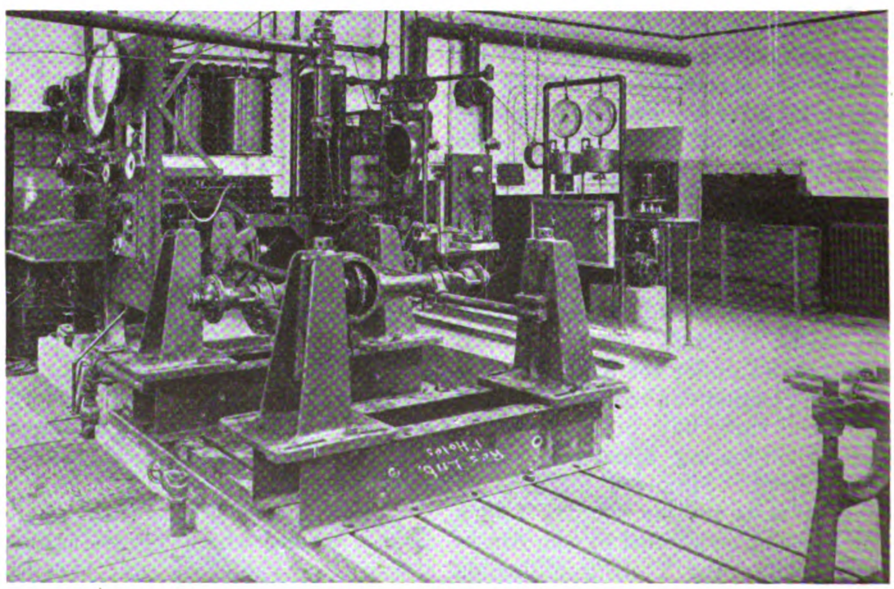
Specific gravity of an oil is the weight of a volume of that oil compared with the weight of an equal volume of water, the comparison being made at 60 deg. F. Specific gravity may be determined in several different ways; the hydrometer method is the one most commonly used.

Beaume gravity is an arbitrary scale giving direct readings in degrees which denote the density of the liquid; the higher the number on the scale the lighter the oil is. For example, an oil having a Beaume reading of 24 deg. has a specific gravity of 0.9091, which means that the weight of a gallon of that particular oil is only a trifle more than 0.9 that of a gallon of water. Most oils are lighter than water, although there are a few heavy residual products which violate this rule.

The gravity or weight of an oil is not a determining factor of its lubricating value. Practically the only value this test has is to assist in determining, in conjunction with other tests, the type of crude oil from which the lubricant was extracted.

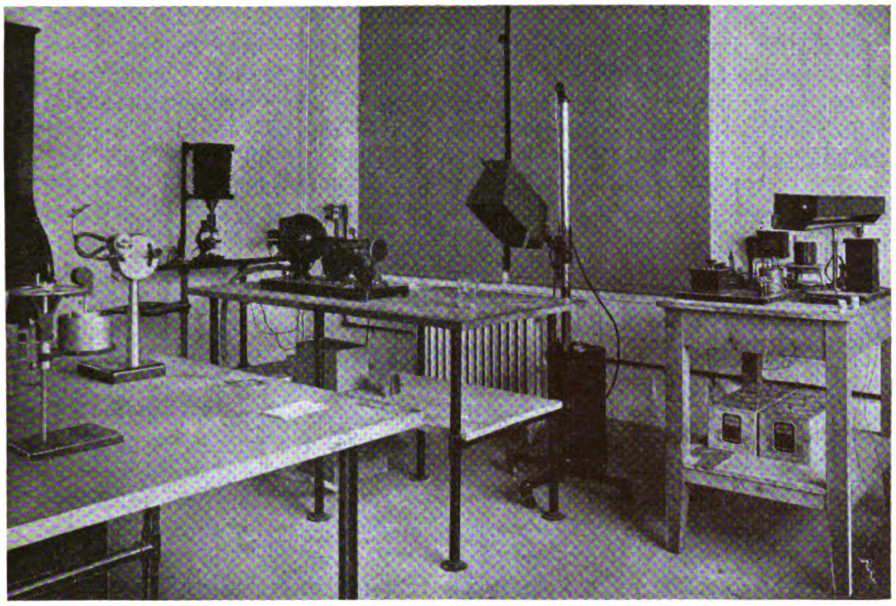
The *flash test* is made by putting a quantity of oil into a vessel and raising the temperature at a uniform rate. The temperature of the oil in the vessel is carefully noted at intervals just before applying a test flame to the vapors arising from the heated oil. The lowest temperature at which the oil vapors "flash" momentarily on the application of the flame, is the flash point of the oil. This flash point is denoted in degrees Fahrenheit or Centigrade, as the custom may demand.

The test may be made in an open cup or in a closed cup. The flash point resulting from the closed-cup



Most of the advance in lubrication practice has been due to the studies made on automobile bearings.

This view shows a dynomometer test. The study of the use of lubricants by such laboratory tests, the results of which are checked against practical operation, has given lubrication engineers a much better knowledge of what friction is, how it may be reduced, and the effect of oils of different characteristics under various operating conditions. Similar studies and investigations have been made in industrial lubrication problems.



Another section of the testing laboratory where oil problems are studied.

Standard tests are established by the American Society for Testing Materials for determining the various characteristics of oils. Many of these tests require special apparatus and considerable care and experience to get reliable results. Industrial plants which desire to test their oils and do not have a laboratory and trained chemist, may have their tests made at commercial laboratories.

test, however, is considerably lower than that of the open-cup test because the closed cup prevents the escape of the oil vapors, and a combustible mixture of air and oil vapor is produced at a lower temperature than in the open cup.

The minimum flash point of lubricating oils is about 300 deg. F. for the lightest grades. With increasing viscosity the flash point rises and in the residual oils may be as high as 600 or 700 deg. F. The lubrication of high-pressure air compressors and steam cylinders using superheated steam is about the only type of industrial work in which the flash point is of any consequence. However, most flash trouble in air compressors can be traced to too much lubrication rather than a low flash point. Incidentally, the flash point is also important in the case of tempering and transformer oils, although these applications do not come under the head of lubrication problems.

The *fire test* is conducted in the same way as the flash test; the heating of the oil is continued until the vapors from the heated oil will not only "flash" but continue to burn when the flame is removed. The minimum temperature at which the oil ignites and continues to burn is the fire point of the oil. This point is always higher than the flash point.

The flash and fire tests of any good grade of lubricating oil are sufficiently high for the work for which the particular manufacturer recommends the product. Flash and fire tests are of value in the lighter oils, such as kerosene, none of which is suitable for use as a lubricant.

The *pour test* of an oil signifies the lowest temperature at which the oil will flow or pour out of a container. The greatest care should be taken in arriving at a result in a pour test as it is quite easy to obtain several different readings for the same oil.

The *cold test* of an oil is the temperature at which the oil congeals and refuses to flow. This temperature is usually a few degrees lower than the pour test. The two tests are sometimes spoken of interchangeably, but this is erroneous as there is a distinct difference between the pour test and the cold test. An oil that has a pour test of 10 deg. F. might have a cold test of 5 deg. F.

Lubricants for Outside Use Require a Low Cold Test

A variety of devices is used to determine the cold test of an oil. However, an ordinary test tube is quite satisfactory. The oil should be placed within the tube and cooled slowly and the temperature noted on a thermometer which is placed in the oil. The lowest temperature at which the oil will still flow when the tube is tilted is the pour test of the oil. Careful observation and some experience are required to make this test of value. The cold test is, of course, noted at a little lower temperature when the oil loses its mobility and assumes the aspect of a solid.

The cold test is only important when fluidity is demanded under low-temperature conditions, as in outdoor service, such as railway work, quarrying and mining or any work in which machinery is used under low-temperature conditions. Drives and oil bearings on conveyors, pumps and other equipment which is often placed in unheated and poorly-sheltered locations should receive the same attention in winter time as an automobile, and have the oil changed. An oil intended for indoor use will cause a heavy friction load, particularly at starting time, if used in exposed locations in winter. Refrigerating machinery presents a low-temperature service problem where a high-grade, low cold test oil is an absolute necessity.

The *volatility or evaporation loss* of an oil is sometimes determined. This loss is evidenced in the loss of weight of the oil when the oil is exposed to high temperature for a specified time. In order to make this test, the oil is placed in an open vessel, heated, and maintained at a definite temperature. The difference in weight between the original oil and the remaining quantity of oil is the evaporation, which is reported as a percentage loss.

There are so many variables present in testing for volatility that the test is not likely to be very accurate. The nature of the container, the method of heating the oil, and the atmospheric or barometric pressure at the time of making the test, all enter into the final results. The volatility test is quite unimportant in lubricating oils, as any good grade of oil over 300 deg. F. flash point will have a volatility loss that is practically negligible.

The *specific heat* of an oil is a measure of the quantity of heat required to raise the temperature of 1 lb. of oil 1 deg. F., as compared with the quantity of heat required to raise the temperature of 1 lb. of water 1 deg. F. The specific heat of a lubricating oil is not of serious importance as regards lubrication itself. When lubricating oils are used for heating baths, fluid mediums and other similar purposes, specific heat may then become a factor as a heat transfer medium.

However, it is interesting to note that the specific heat of oil is about one-half that of water, but varies

with the viscosity, temperature and gravity, and with the different types of oils.

The *body or viscosity* of an oil is probably the test which the purchaser is most interested in and the one upon which he will very likely select an oil for a specific job. This test is conducted by means of a viscosimeter. In this country, the instrument used is the Saybolt viscosimeter, while Great Britain uses the Redwood, and continental Europe the Engler. The Saybolt readings are tabulated in seconds of time, and the Redwood and Engler in degrees.

Briefly, viscosity is the time in seconds required by a given quantity of oil to flow through a standardized orifice at a definite temperature. This is the Saybolt method of measurement and is probably the most widely used. Viscosity readings are ordinarily taken at various temperatures between 100 deg. F. and 210 or 212 deg. F.

It must not be supposed that because two oils have the same readings at say, 100 deg. F., they will also have the same viscosity at 160 or 180 deg. F. Some oils, due to their origin and blending, retain their body better than other oils which are apparently the same. Such oils may have a lower viscosity at the lower temperature and a higher viscosity at the highest temperature; that is, a more constant body is retained by the oil over a wide range of temperatures. This characteristic is very desirable in a lubricating oil, especially for conditions where there are fluctuations of temperature. At the lower temperature, the internal friction of such an oil is relatively low, whereas at the higher temperature the same oil will maintain its body and lubricating capacity. Wide range of viscosity due to temperature fluctuations is generally an undesirable feature of a lubricating oil and one that should be avoided as far as possible. This is not so essential when selecting an oil for a definite operating temperature.

How Viscosity Affects the Use of the Lubricant

Lubricating oils vary in viscosity from 60 sec. Saybolt to over 3,000 sec. at 100 deg. F., beyond which the oils assume the consistency of semi-solids. The lighter oils are used for light, high-speed work where small clearances are the rule. As they increase in body, they find their usefulness in the slower and heavier work where the clearances are larger and where a thicker film of oil is necessary.

Viscosity of an oil is sometimes an indication of its fitness for a particular job. For example, a bearing with no mechanical imperfections, may run quite warm when an oil of a certain body or viscosity is introduced. When an oil of a little lower viscosity is introduced, the temperature of the bearing will drop many degrees. This drop in temperature is due to the lower friction loss in the oil itself. The lighter oil having less internal friction naturally absorbs less power as the shaft rotates and consequently produces less heat. Such power losses quickly run into money losses in terms of unnecessary power or fuel. High bearing temperatures may be due to the use of oil of a viscosity unsuited to the work and are not necessarily indications of imperfect mechanical conditions or abnormal pressures.

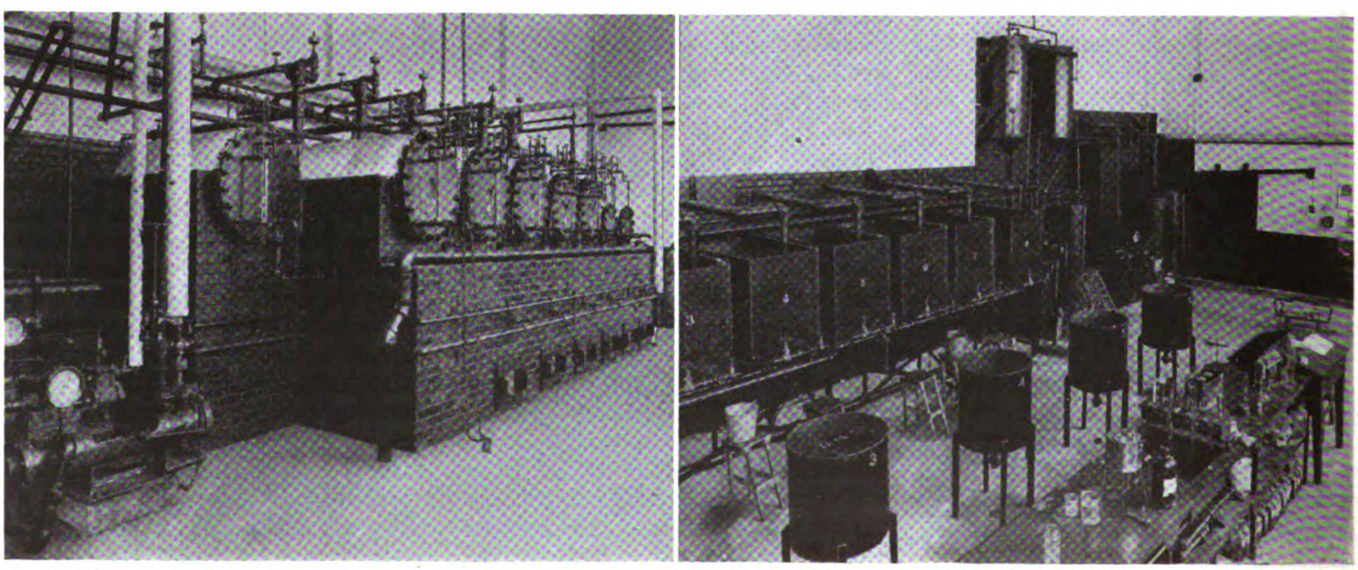
For steam cylinder lubrication, the viscosity of the oil is an important factor. Steam pressure and temperature, the speed of the engine, the load and consequently the volume of steam passing into the cylinder, are factors in determining the body of the oil to be used in the cylinder. In the first place the oil must be easily atomized; it must be broken up by the steam and distributed to all internal parts requiring lubrication. It must not have too heavy a body to do this. Next, it must seal and lubricate the valves, piston, and cylinder walls so that the full power of the steam may be utilized in pushing the piston forward. These two factors must be considered carefully in selecting the steam cylinder lubricant. Viscosity enters into the selection to the extent that the oil will neither be too heavy to be distributed by the steam nor too light to seal the piston and lubricate the parts.

Lubricating oils made from Western crudes are high in viscosity at low temperatures as compared with oils made from the Eastern crudes, but they decrease in viscosity much faster as the temperature is increased. The first mentioned are asphaltic base oils, whereas the Eastern crudes are paraffin base oils.

Selecting a lubricant for a particular service is a task which calls for a thorough knowledge of lubrica-

Economical manufacture of standard quality products is studied in experimental refineries such as are shown here.

These illustrations show two experimental distilling units where actual refining processes are carried on in miniature and the product produced under properly controlled laboratory methods.



tion and of the source and manufacture of the oil. Since viscosity is the most common characteristic used in selecting an oil for any particular purpose it is well to keep in mind that the oil which should be used depends upon the temperature of the bearing, the pressure on the bearing, the speed, the type of bearing, and the method of application. The following generalizations may be made:

(1) High pressure requires high viscosity oil. (2) High temperature requires high viscosity oil. (3) High speed requires low viscosity oil. It is obvious that many installations necessitate a compromise on these factors, particularly when it is remembered that additional complications arise due to the type of bearing and method of application. In general it is well to select an oil which is of medium viscosity, as between the heavy and light viscosities which would be indicated as desirable by the three generalizations mentioned.

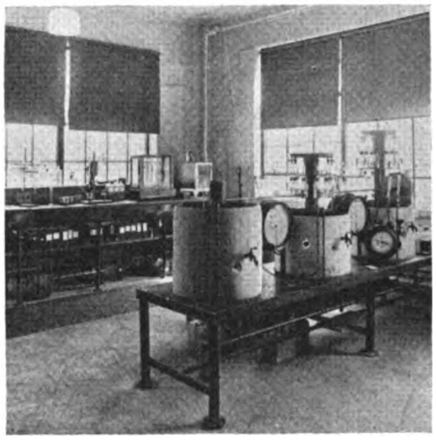
While viscosity is one of the more important "tests" or specifications of lubricating oils, it should be remembered that, after all, it is merely *an indication* of the fitness of an oil for a job. It is in no sense a guarantee that the right oil has been selected.

Oils that are subject to long, continuous use, as in circulation systems of steam turbines, or steam engines, or in the crankcases of internal combustion engines where there is likely to be contamination with water or other impurities, must have a special quality that resists the formation of an emulsion. This means that compounding of mineral oils with animal or vegetable oils is prohibited, as these oils emulsify readily when mixed with water. Mineral oils, on the other hand, do not mix easily with water but even with what is known as "straight mineral" oil, there is a difference in the resistance to water contamination, technically known as "demulsibility."

Only high-grade oils, especially treated and manufactured will resist the tendency to emulsify. With proper care they will retain their original characteristics over long periods.

The *demulsibility test* is a measure of the tendency of the oil to separate from water and is useful only in determining the separating qualities of oils manufactured especially to resist emulsification in service. It is only one of many testing methods in use by the oil refiner in producing oils for lubricating purposes.

There are other tests which are more a problem for the oil chemist than for the purchaser or user of oils. For instance, the *acidity test* is used to determine what, if any, acids may be present as a result of adulteration or improper refining. An oil which has not been well neutralized will sometimes change its characteristics during use or storage. Freedom from acidity is important in Diesel engine lubrication.



Problems in connection with transformer oils are studied in this part of the laboratory.

While transformer oil requirements differ somewhat from those required for lubricating oils, some of the testing procedure and the specifications are based on similar tests for both. One of the tests of particular importance for a transformer oil is the sludge test, which indicates how long an oil will stand up without the formation of a sludge which would decrease its insulating value. Also, a transformer oil must be well neutralized.

The *sludge* test, which determines the tendency to form a sludge, has comparatively little bearing on lubrication, but is of interest to the manufacturer and important in determining the insulating life and value of transformer oils. The *breakdown test*, which indicates the temperature at which the oil begins to "crack" and "break down" into lighter and more volatile oils, is of little value in that practically none of the lubricants will break down under 650 deg. F., which is far above the temperatures encountered in ordinary usage. This test is, however, sometimes made on turbine oils.

Such tests require the services of an expert chemist. They cannot be properly classified under the term "specification," although they have to do with the nature and make-up of the oil.

Greases are not tested in the same way that oils are, owing to the great differences in their nature and characteristics. Instead of speaking of "viscosity" when referring to grease, the term *"consistency"* is used. The only quality tests that can be conducted on greases are those for determining the presence of free acid or alkali. Such tests do not establish the lubricating value of a grease nor do they indicate the uniformity of the product. It can only be said that uniformity is not so readily determined in grease products as it is in lubricating oil products.

It is evident from the foregoing paragraphs that the chemical and physical tests which are applied to lubricants, especially to oils, in no way evaluate the oils as lubricants. Lubrication in the true sense of the word demands more than the application of an oil to a bearing or other machine part that may require oil so that the machine will run without wear or renewing of parts; that is only one phase of the industrial problem.

True lubrication is the application of the oil: (*a*) for the maintenance of a complete and perfect film; (*b*) for the maintenance of the perfect film with the minimum of friction and power consumption; (*c*) economical application.

The solution of the lubrication service problem does not lie in securing oils answering to a certain set of specifications. It does not consist of a comparison of several sets of specifications and selection of the oil for the job by theoretical analysis.

Bearing lubrication is a practical problem and one that is solved best by the study and observation of the practical use of lubricants under conditions of actual service. This involves the practical demonstration of the suitability of the oil for the work, its ability to meet the conditions of service, and its capacity for continued performance over a period of time. The correct oil for a purpose is the result of the study of lubrication problems and the development of a lubricant to satisfactorily meet the conditions when used properly.

In order to produce oils uniformly, the manufacturer must gage his product against certain standards or specifications which are determined by tests, so that when the customer buys a brand of oil, whether it be

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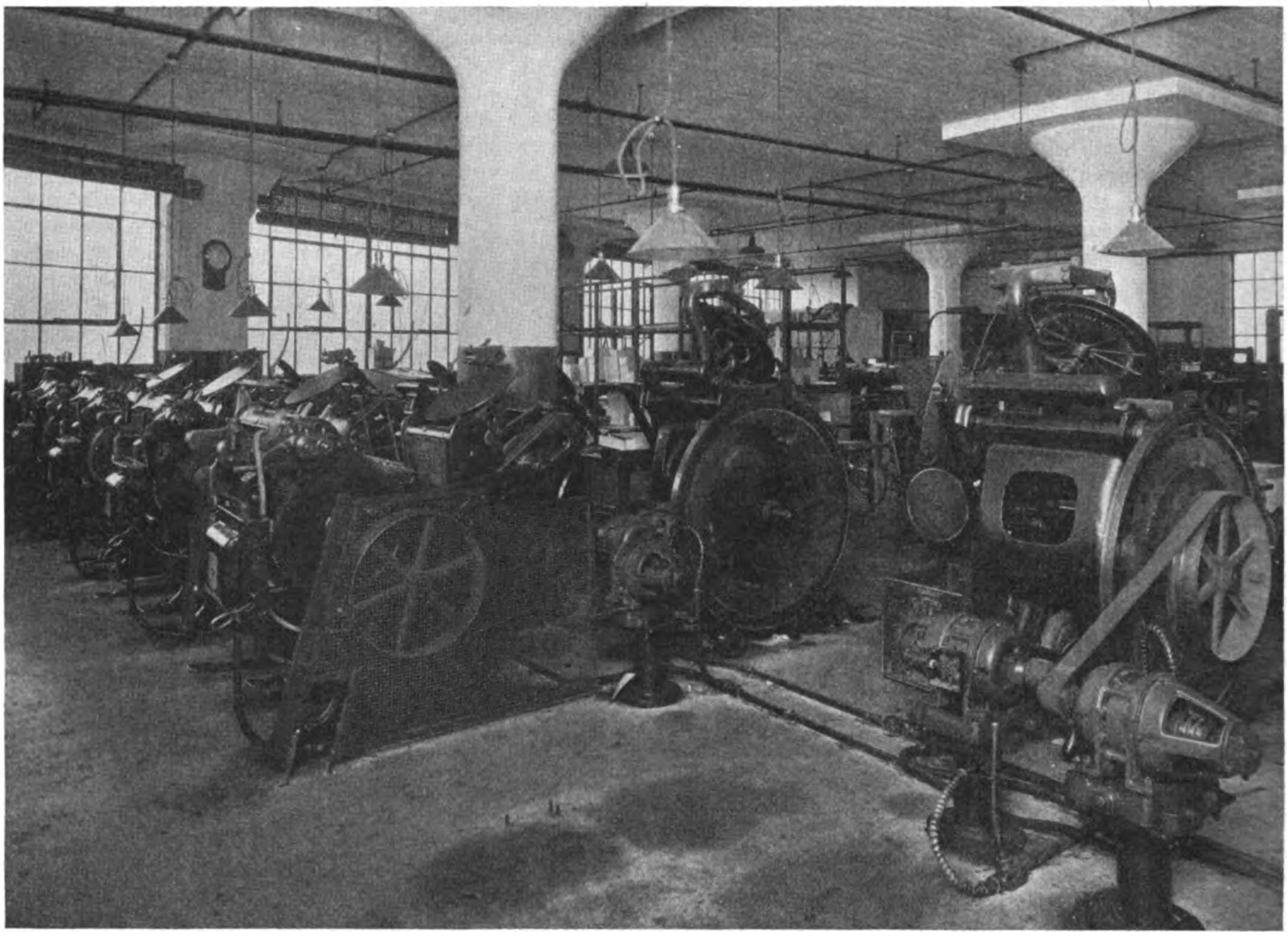

Fig. 1—Belt drives are used almost exclusively in this plant.
Individual drive is used throughout and belt drive is an economical method of reducing the high motor speed to the low speed required at the presses. Note the use of pedestals for mounting the motors and the convenient location of the motor starting switches with reference to the machine operators.

Power Service Layout for Small Motor Drives

including features of the electrical distribution system, the manner of mounting the motors, and the types of control and drive connections used

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ALTHOUGH laying out a power service installation for a large group of machines requiring only small amounts of power may not seem as difficult as the power layout for the usual mill or factory, still there are many questions to be considered, upon the solution of which rest both the size of initial investment required and the economy of operation after installation.

The Brooklyn plant of Library Bureau furnishes an interesting example. In this installation careful consideration was given to these factors by MacNutt, Watts, and Tankard, electrical engineers and contractors of New York, N. Y., who designed and erected the installation of motors and power drive equipment described in this article.

Library Bureau is a manufacturer of card catalog and filing systems, and various office equipment. The Brooklyn plant of this company specializes on printing and paper products; hence this plant is much in the nature of a printing establishment although it does not have the large presses found in many job printing and newspaper plants.

As might be expected, the power requirements of the individual machines are very small—in only three instances do they exceed ¾ hp. per machine, as may be seen from the accompanying table showing the sizes of motors for the various applications. Also, most of the machines occupy considerable space, compared to the size of the motor used. These factors had a decided bearing on the type of drive that should be used. Group drive was out of the question because the friction losses would be as large as the load itself. Also, many of the machines require from 12 to 15 different speeds; hence individual drive was used throughout and in most cases the motors were connected to the machines by belts except where extremely low speeds were required, when back-geared motors were belted to the machines. The problem then was to supply a large number of small power services.

The building which houses the plant is a new concrete structure

and is provided with conduit built in during construction. Outlets are provided on each floor at practically every post and pilaster on the floor. This feature greatly simplified the conduit layout as it was necessary to provide only the conduit running from these outlets to the individual motors.

Three-phase, 220-volt power was brought into the basement as shown in Fig. 2. A cabinet encloses the switches controlling the power and light supply as well as their respective meters. The supply then passes through the large distribution cabinet shown at the left of the illustration. Two sets of buses will be noticed; the set on the left is for the three-phase power supply, while the set on the right distributes the lighting supply. Individual feeders starting from fuses connected to the buses go to each floor through vertical conduit runs from this panel.

On each floor is a polarized panel box similar to the one illustrated in Fig. 3. A polarized panel box is one in which all wires of one phase are grouped together; in the illustration each door opens into a compartment housing the fuses and bus for one phase. The panel box, shown in the illustration, is centrally located on the fifth floor and has 40 circuits. This type of box saves space, especially where induction motors, requiring three wires, are used. From these distribution panels, conduits radiate to outlets on the posts and pilasters on the floor. These outlets are placed approximately 6 in. above the floor level. From these outlets conduits are run on top of the floor to the individual machines, as shown in Fig. 1. In most instances the conduit could be laid on the floor so as to be parallel to an aisle of machines, as shown in Fig. 1. Placed in this way the conduit does not obstruct traffic in the aisles and the conduit on the floor between machines causes no more trouble than the motors and other equipment around the machines.

Motors, Control, and Drive Connections Used in a Printing Plant

Name of Machine	Hp. of Motor	R.P.M.	Type of Motor	Control	Drive
10-in. Saw table	3	1,800	Squirrel cage	Man. start. switch	Belt
7x¼-in. Grinder	½	1,800	Squirrel cage	Man. start. switch	Direct
Small drill	½	1,800	Squirrel cage	Man. start. switch	Belt
Dewey ruling machine	½	1,200	Wound rotor	Start sw. & sec. res.	Belt
Hickok ruling machines	½	1,200	Wound rotor	Start. sw. & sec. res.	Belt
No. 1C Chandler & Farquhar punch	½	900	Squirrel cage	Man. start. switch	Belt
Dewey punches	½	1,200	Squirrel cage	Man. start. switch	Belt
Tabbing machines	½	900	Squirrel cage	Man. start. switch	Belt
E-1 Harris presses	1	1,200	Wound rotor	Start. sw. & sec. res.	Belt
J. T. Robinson rotary board cutters	1½	1,200	Squirrel cage	Man. start. switch	Belt
J. T. Wright paper drill	¼	1,800	Squirrel cage	Man. start. switch	Belt
26-in. Rotary board cutter	½	1,200	Squirrel cage	Man. start. switch	Belt
14-in. Auto feed rotary board cutter	1	1,800	Squirrel cage	Man. start. switch	Belt
Small punch	⅓	1,200	Squirrel cage	Man. start. switch	Belt
Intertype machines	⅓	1,200	Squirrel cage	Man. start. switch	Belt
F. Wesel Prof. press	⅓	1,200	Squirrel cage	Man. start. switch	Belt
Multi-color auto feed press	¼	1,800	Squirrel cage	Man. start. switch	Belt
15x21 Golding job presses	¾	1,800	Squirrel cage	Man. start. switch	Belt
8x12 Golding job presses	¼	1,800	Wound rotor	Start. sw. & sec. res.	Belt
12x18 Golding job presses	½	1,800	Wound rotor	Start. sw. & sec. res.	Belt
12x18 Miller feeder press equipment	¾	1,800	Wound rotor	Start. sw. & sec. res.	Belt
10x15 Miller feeder press equipment	½	1,800	Wound rotor	Start. sw. & sec. res.	Belt
8x12 Golding job presses	¼	1,800	Wound rotor	Start. sw. & sec. res.	Belt
7x11 Golding job presses	¼	1,800	Wound rotor	Start. sw. & sec. res.	Belt
10x15 Thomson press	½	1,200	Wound rotor	Start. sw. & sec. res.	Belt
Miller saw trimmer	½	1,800	Squirrel cage	Start. sw. & sec. res.	Belt
Metal edge box machine	1	1,200	Squirrel cage	Start. sw. & sec. res.	Belt
Sheridan cutter	2	1,200	Squirrel cage	Man. start. switch	Belt
Miehle vertical presses	1½	1,200	Squirrel cage	Man. start. switch	Belt
Hoole numbering machines	⅓	1,200	Squirrel cage	Man. start. switch	Belt

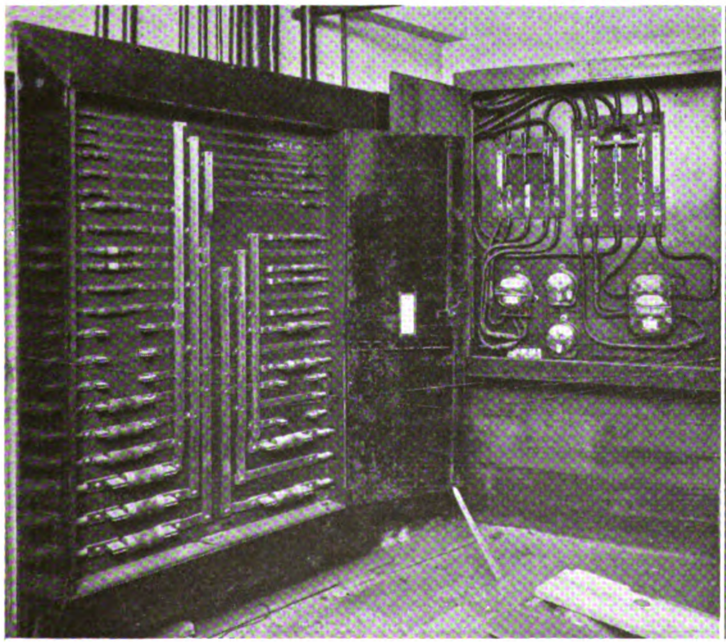
Man start switch refers to a manually operated motor starting switch, which throws the motor across the line without fuses and afterwards cuts in the fuse protection.

Sec. res. given in the control column, refers to the rheostat in the rotor circuit of wound rotor motors and is used for speed control.

There are a total of 57 motors in this installation. Only the types of applications are listed, the number of motors under each application not being included.

Figs. 2 and 3—Distribution cabinets form the backbone of the power wiring on this job.

The service entrance is shown in the switch and meter cabinet in the illustration at the left. The left-hand switch is for the lighting service while the switch at the right controls the power service. Leads from the power switch run to the left-hand set of busbars in the distribution cabinet, from which run feeders to the various floors of the building. Polarized distribution cabinets, as shown in the right-hand illustration, distribute the individual circuits on a given floor.



Where conduit crosses an aisle, a shallow trench was cut in the floor, the conduit placed therein and covered with cement.

After going across the aisle, the conduit was carried on top of the floor. Three-way or "T" conduit fittings were used for junctions to motors and control.

Rigid conduit was used throughout except for the short stretch of flexible conduit connecting the conduit fitting on the motor to the rigid conduit. This may be seen in Fig. 1. One of the presses in the immediate foreground has been temporarily moved away—its motor can be seen standing second from the right in the foreground.

The arrangement used for enclosing the motor leads can be seen on this motor. These motors were not equipped with fittings to enclose the motor leads and receive the conduit; so an ordinary knockout box, having a hole large enough to go over the outlet for the stator leads, was bolted to the stator frame by means of four machine screws. One of the punchings was knocked out of the side of the box towards the rotor leads (in the case of a wound-rotor motor, as shown in the illustration) and a piece of flexible conduit connected thereto and to the end bell through which the rotor or slip-ring leads passed. A punching was knocked out of the top of the box and flexible conduit was run from this point to the rigid conduit. All splices were made in the knockout box.

Most of the motors were mounted on the concrete floor, as shown in Figs. 1 and 4. A few, however, were mounted on the frames of the machines themselves, as shown in Fig. 5. The linotype machines have special bases provided on the frames, as also do some of the smaller presses which have a friction drive through a belt working over an idler, and pressing against part of the periphery of a flywheel, as may be seen in the center of Fig. 1.

Some of the motors for the presses were mounted on pedestals as can be seen in Fig. 1. These pedestals are very simple, consisting of two 6-in. pipe flanges, a short length of 6-in. pipe and two pieces of strap iron. The pipe was threaded and one flange screwed tightly to each end. One flange was then bolted to the concrete floor and the two pieces of strap iron bolted to the other flange to form a base on which the motor slide rails were mounted.

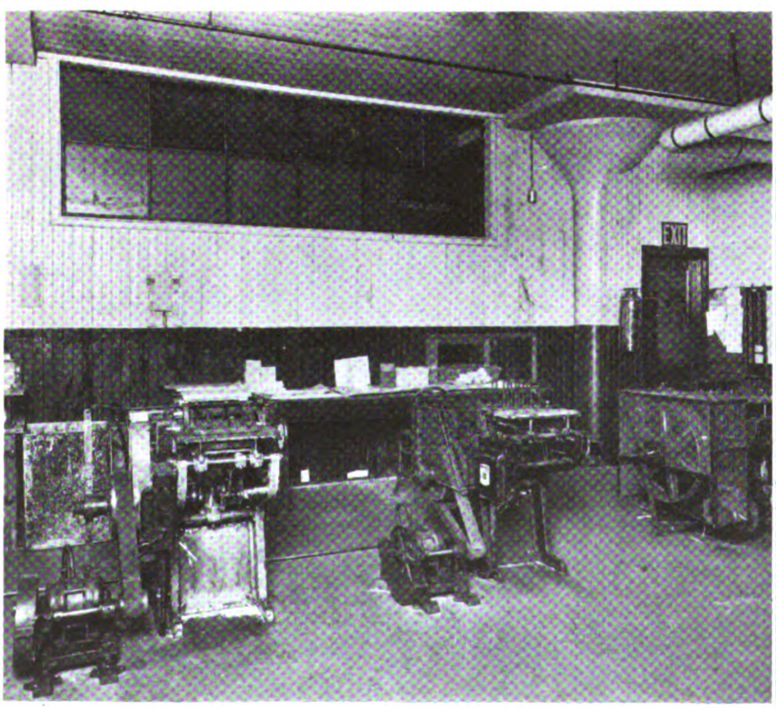
From the accompanying table it will be seen that three standard motor speeds were required: namely, 900, 1,200 and 1,800 r.p.m. With the exception of the presses and ruling machines, these motors are of the constant-speed, squirrel-cage type and are belted to their respective drives. The presses require adjustable speed, in some cases as many as 12 or 15 different operating speeds, depending upon the character of the work being done. Wound-rotor induction motors were provided for this service.

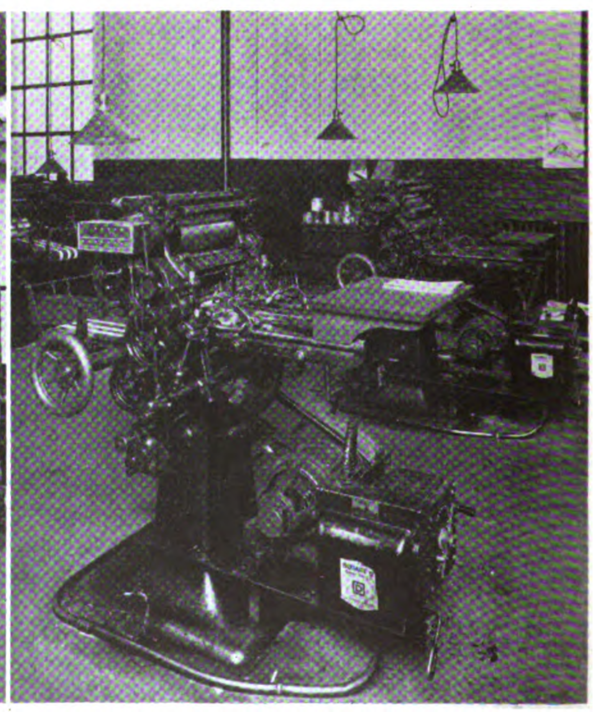
The class of labor that operates these machines is of a high order of intelligence; so it was unnecessary to reduce the control methods used to a matter of push-button switches. Manually-operated, across-the-line starting switches are provided for all motors, as may be seen in Figs. 1, 4 and 5. In addition, the variable-speed motors are provided with a manually-operated rheostat which increases or decreases the resistance in the rotor or secondary circuit to obtain the desired motor speed.

Inasmuch as all of the drives are through belts, with the addition of a few back-geared motors, it was necessary to provide guards. In all cases these were made of coarse wire netting formed over strap-iron frames. Good examples of these guards are seen at the left of Fig. 1 and at the right of Fig. 4. In the case of the Harris presses (shown in Fig. 5) it was possible to mount the motor, starting switch, and speed control rheostat all on one frame, which was fastened to the base of the press. It was then a simple matter to run a wire netting guard around the short stretch of belt.

Figs. 4 and 5—Drive arrangements for automatic cross cutters and high-speed card presses.

At the left is shown the use of back-geared motors belted to cross cutters used for cutting cards. The motors are mounted directly on the floor and in under the machines to save floor space. The same idea is carried out in the right-hand illustration, showing the complete power drive equipment for the high-speed card presses mounted on an angle-iron frame which is bolted to the machine base. The rheostat for varying the motor speed may be seen mounted on this frame directly behind the motor starting switch. It is operated from the front.





Here are some practical ways for

Recording Rewinding Data for Cross Connections

together with the details of typical jobs on which accurate information is essential when laying out and checking up a new winding

THE CROSS or equalizer connections provide a factor of safety against circulating currents between brushes of like polarity, due to changes in the magnetic field of a direct-current machine caused by bearing wear or other conditions that make the armature operate in unequal magnetic densities under the different field poles. Equalizer connections are mostly used on large machines with lap windings or with wave windings having more than two circuits. In some rotary converters the collector rings and their taps to the winding are used as cross or equalizer connections also. In other cases the spacing of the alternating-current taps is different from the cross connector spacing. These details are discussed in the examples presented in this article.

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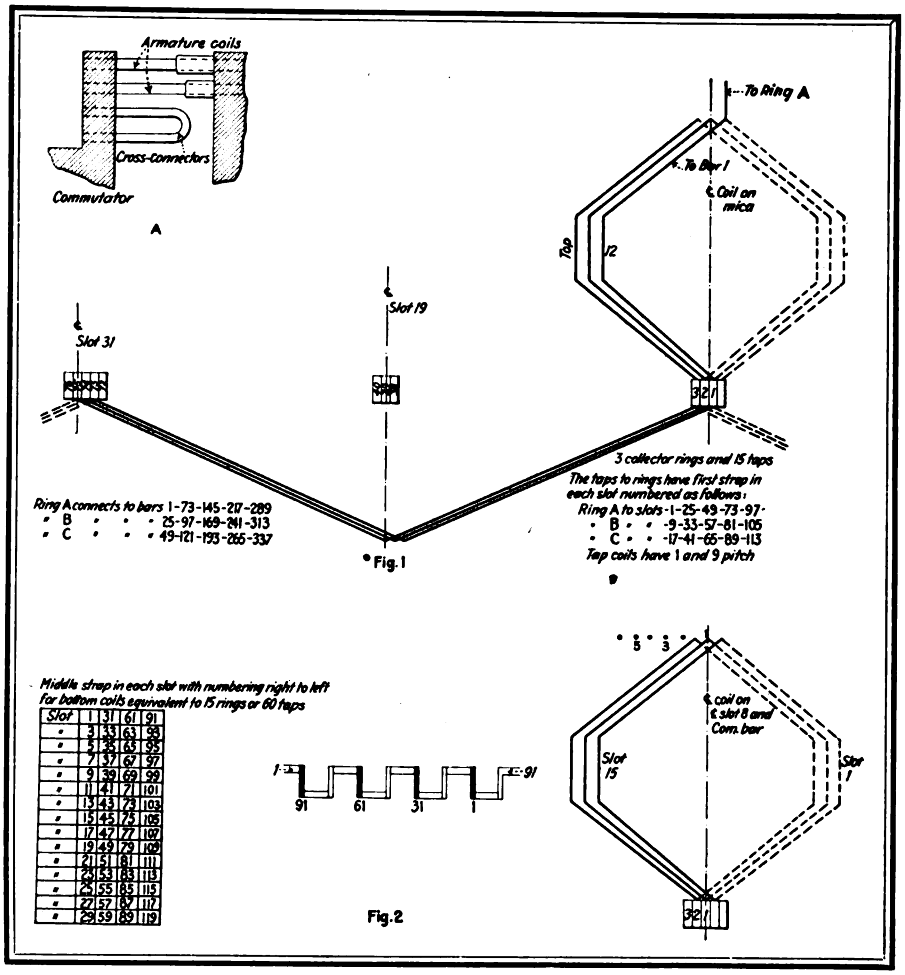
IN THE article that appeared in the January, 1926, issue of INDUSTRIAL ENGINEER, some practical rules governing the use of cross or equalizer connections were given. In this article examples of the application of the connections are presented, together with methods of recording rewinding data for special machines, as an aid to the winder when checking rewound machines with the original winding and also when laying out a new winding.

In Fig. 1 the winding data are given for a 300-kw., ten-pole, three-phase, 60-cycle, 720-r.p.m. rotary converter, having 120 slots, 360 bars and three coils per cell. This winding also has three a.c. collector rings with five taps per ring, as will be explained under rotary converters. The data in Fig. 1 apply to a winding that has the cross connections behind the commutator in the form of a two-layer winding as shown in Fig. 1 of the January, 1926, issue and the small sketch at *A* in Fig. 1 of this article.

The procedure for taking and checking the data, for cross connections is outlined in what follows: Disregard the taps to the collector rings or consider this as a lap winding with cross connections only. By inspecting the commutator necks or risers, the cross connection taps can be located, and the spacing noted. Then select any one bar that has an equalizer connection attached to it and trace out the coil that connects to the bar. If the machine is less than 100 per cent equalized then check the strap (that is middle, etc., single coil) that connects to the equalizer bar. Trace out the complete coil and mark the top and bottom slots and then draw a sketch like Fig. 1 showing the armature coil. Next, with a test light find the other end of the cross connector, which will be the number of bars divided by pairs of poles on either side of the bar selected. Then line out from the bar to which the other end of one cross connection is at-



Slot	1	31	61	91
"	3	33	63	93
"	5	35	65	95
"	7	37	67	97
"	9	39	69	99
"	11	41	71	101
"	13	43	73	103
"	15	45	75	105
"	17	47	77	107
"	19	49	79	109
"	21	51	81	111
"	23	53	83	113
"	25	55	85	115
"	27	57	87	117
"	29	59	89	119

Fig. 1—This is the winding diagram of a 300-kw., ten-pole, three-phase, 60-cycle, 720-r.p.m. rotary converter having 120 slots and 360 bars with 360 cross connectors.

Fig. 2—Diagram for recording rewinding data for 1,000-kw., eight-pole generator with lap winding in 120 slots, 360 bars, three coils per cell. Every other slot is cross-connected.

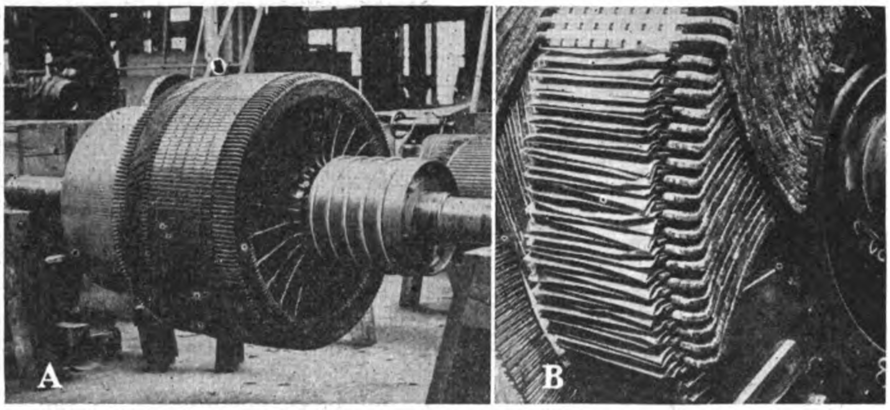


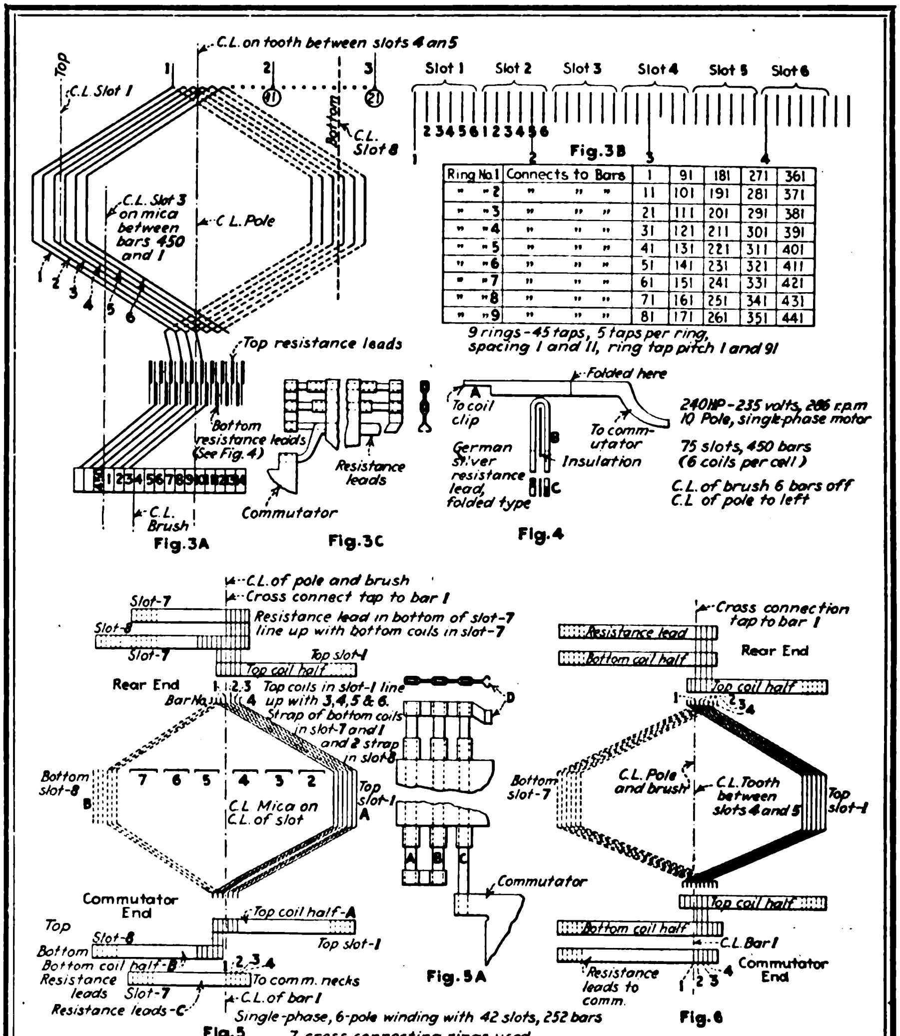
Fig. 7—In A is shown a rotary converter armature, with four collector rings, for a 250-hp., two-phase, 12-pole machine. In B, showing the rear end of the armature, the a.c. taps from the bottom of the tap coils and also the spacing of these coils can be seen.

tached, to the slot on a line with this bar and mark it off on the sketch as shown. Also locate the center line of the cross connector on a bar and slot, etc.

If the keyway in the shaft is in view, it is better to find the slot or tooth that is on the center line of the keyway. Then use this in locating a data coil. This will be shown later.

In Fig. 2 is shown the method of recording the rewinding data for a 1,000-kw. generator, eight poles, lap winding, 120 slots, 360 bars, three coils per cell, coil pitch 1-and-15. The cross connections, at the rear of the armature are as shown in Figs. 6 and 7 of the January, 1926, issue. In this case slot numbers are used in locating the cross connections as indicated in the table of Fig. 2. The spacing in bars or single coils, is 1-and-7, the connector pitch being 120÷4=30 in slots and 360÷4=90 in bars. Note the method of indicating the cross connector data at the rear end of the armature. The dots each represent a slot and the numbers of slots are the ones to which a connection is made to the middle strap in the slot indicated.

Figs. 3A, 3B and 3C illustrate the method of recording rewinding data on a difficult job: namely, the armature of a large, single-phase, series-type motor. The armature has resistance leads and cross connections in the form of nine rings at the rear end, similar to Fig. 5 of the January, 1926, issue. Fig. 3C shows that the winding uses half-coils, the rear ends being joined together with clips. A special clip is used for the cross connectors, as shown in Fig. 3C. The sketch also shows that the coils are connected to the commutator through resistance leads placed in the bottom of each slot. These resistance leads are made of german silver or other resistance alloy. Those shown in Fig. 3C are made from flat ribbon bent over flat and a piece of insulation placed between the folds. Fig. 4 shows the method of folding. View *A* shows the flat strip with the top and bottom leads punched out. It is next folded along the dotted line, as in *B*, which shows the top view of the folded piece and the insulation between the folds. *C* is the front view. Six of these are tapped together to form a winding unit. Fig. 3C shows the coils are joined together on the front (commutator) end with clips in such a manner as to give the same results as though the coil ends were placed in the commutator necks; that is, a



Ring No. 1	Connects to Bars	1	91	181	271	361
" " 2	" " "	11	101	191	281	371
" " 3	" " "	21	111	201	291	381
" " 4	" " "	31	121	211	301	391
" " 5	" " "	41	131	221	311	401
" " 6	" " "	51	141	231	321	411
" " 7	" " "	61	151	241	331	421
" " 8	" " "	71	161	251	341	431
" " 9	" " "	81	171	261	351	441

7 cross connecting rings used

Ring No. 1	To Strap	1	85	169
" " 2	" "	13	97	181
" " 3	" "	25	109	193
" " 4	" "	37	121	205
" " 5	" "	49	133	217
" " 6	" "	61	145	229
" " 7	" "	73	157	241

21 taps,- spacings 1 and 13, pitch 1 and 85

Figs. 3 and 4—Rewinding data for a large single-phase motor having resistance leads and cross connections in the form of nine rings.

Fig. 4 shows the construction of the resistance leads used as indicated in Fig. 3C.

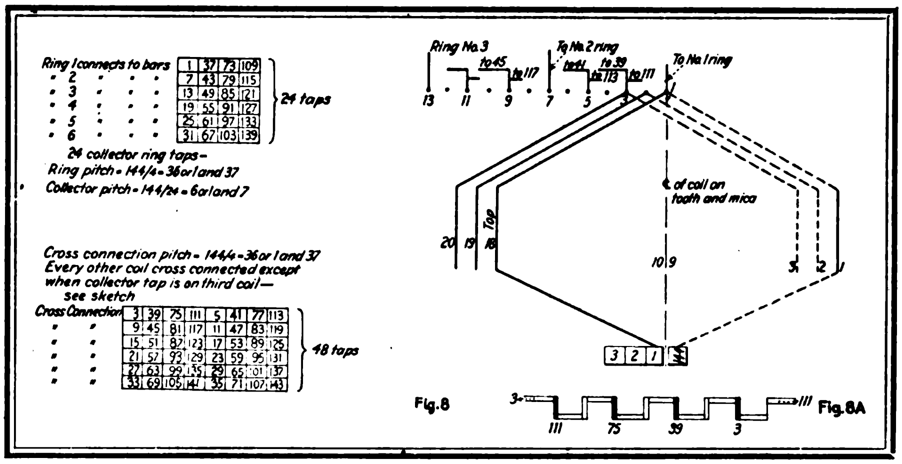
Figs. 5 and 6—Rewinding data for single-phase armature using resistance leads as half-coils and cross connections. Fig. 6 shows another way to record data for this winding.

continuous circuit. Thus the armature circuit is closed through the clips and only the resistance leads that are connected to the bars in contact with a brush are in circuit at any one time.

In taking data on a winding of this type it is best to work downward; that is, start with any one top coil. Mark the slot No. 1, and contrary to previous instructions, make the slot numbers run clockwise. Then find the center line of this top group of coils and make a sketch showing the steps made. At the same time note the equalizer connections and make necessary notations. Then mark the slots and clips and remove enough top coils to expose the bottom coils to view. Next, from the marked clips and slot, trace out the corresponding bottom conductors and fill in the sketch; also mark the slots. Next hold a test light on the front clip that the top strap (No. 1) is connected to and with the other test lead explore the commutator until a light is found on *one* bar only. This will locate bar No. 1. The next step is to locate the slot that contains the resistance leads in contact with top coils *1, 2, 3, 4, 5, 6*. First mark the clips *1, 2, 3*, etc., to correspond with the top strap marking. Then lift enough bottom coils, working back towards slot No. 1, to expose the resistance coils. It is then an easy matter to trace out and note the slot that contains the leads. In this case, the resistance leads in slot No. 4 connect to top straps *3, 2, 1* in slot No. 1, and top straps *6, 5, 4* in slot No. 75. These data are then put down as shown in Fig. 3, which also shows that an equalizer tap is made to top strap No. 1, in slot No. 1. By checking further we find the next tap is made to strap No. 5 in slot No. 2, as the spacing is 1-and-11 or ten. Next, on checking the taps to ring No. 1, we find five taps, one each from straps *91, 181, 271, 361, 1*. Considering the top straps as bars, the cross connecting data are then put down as in Fig. 3*C* and the upper part of Fig. 3*A*.

With motors of this type, when the complete machine is available, it is good policy to mark the pole and brush center line on the commutator by scratching the bar with a knife before removing the armature from the frame. Fig. 3*A* shows that the center line of the pole and coil falls on the mica between bars *9* and *10*, that the center line of the brush is between bars *3* and *4*, and that the center line of *slot* No. 3 falls on the mica between bars *450* and *1*.

In Fig. 5 are shown the data for a single-phase armature with resistance leads and cross connections.

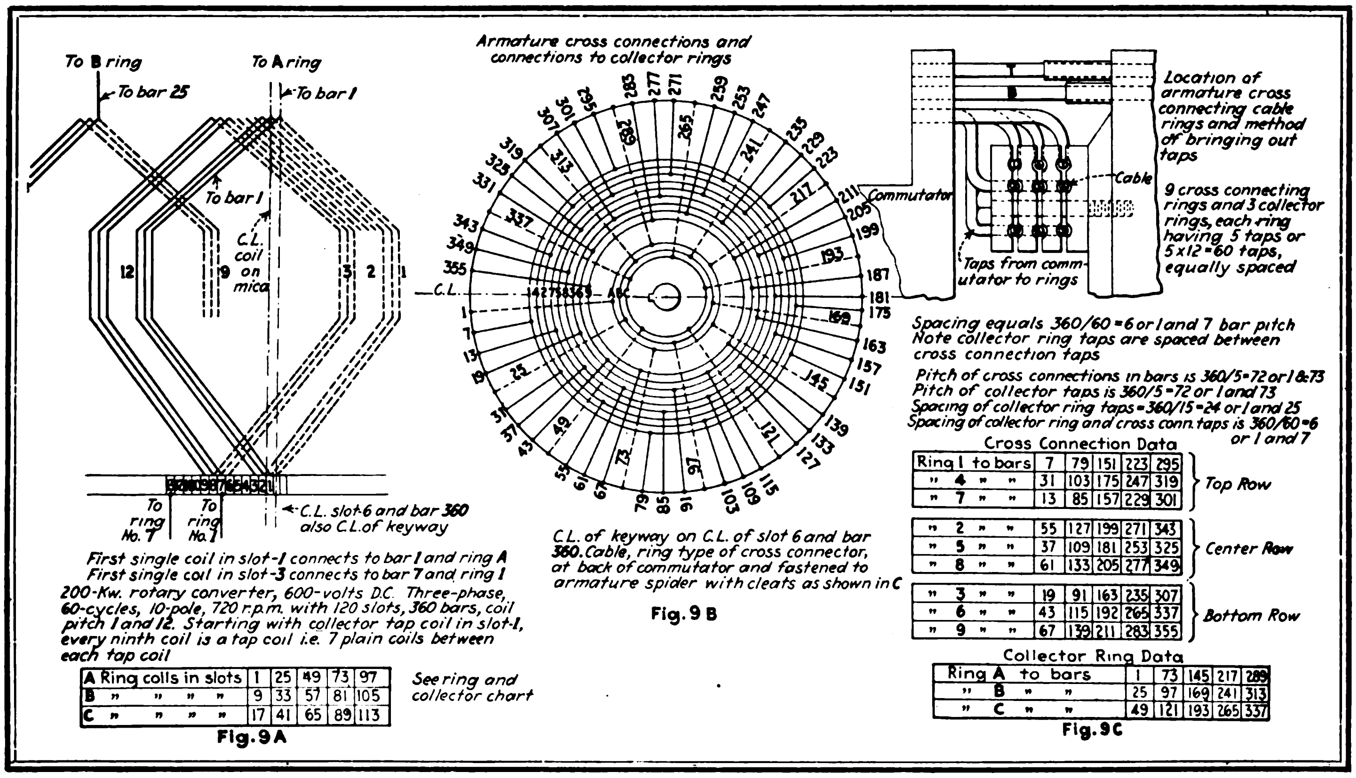


Ring 1 connects to bars	1	37	73	109
" 2 " " "	7	43	79	115
" 3 " " "	13	49	85	121
" 4 " " "	19	55	91	127
" 5 " " "	25	61	97	133
" 6 " " "	31	67	103	139

Cross Connection	3	39	75	111	5	41	77	113
" "	9	45	81	117	11	47	83	119
" "	15	51	87	123	17	53	89	125
" "	21	57	93	129	23	59	95	131
" "	27	63	99	135	29	65	101	137
" "	33	69	105	141	35	71	107	143

Fig. 8—Diagram and data for eight-pole, six-phase rotary converter with 144 slots and bars. Coil pitch is 1-and-18. Six collector rings with the a.c. taps also used as equalizer connections give 50 per cent equalization.

Fig. 9—In A a method is shown for recording data for a rotary converter using flexible cable at the rear of the commutator for the equalizer connections. In B the connections to the collector rings are illustrated, and in C the method of attaching the rings to the armature core is shown.



A Ring coils in slots	1	25	49	73	97
B " " "	9	33	57	81	105
C " " "	17	41	65	89	113

Cross Connection Data

Ring 1 to bars	7	79	151	223	295	Top Row
" 4 " "	31	103	175	247	319	
" 7 " "	13	85	157	229	301	
" 2 " "	55	127	199	271	343	Center Row
" 5 " "	37	109	181	253	325	
" 8 " "	61	133	205	277	349	
" 3 " "	19	91	163	235	307	Bottom Row
" 6 " "	43	115	192	265	337	
" 9 " "	67	139	211	283	355	

Collector Ring Data

Ring A to bars	1	73	145	217	289
" B " "	25	97	169	241	313
" C " "	49	121	193	265	337

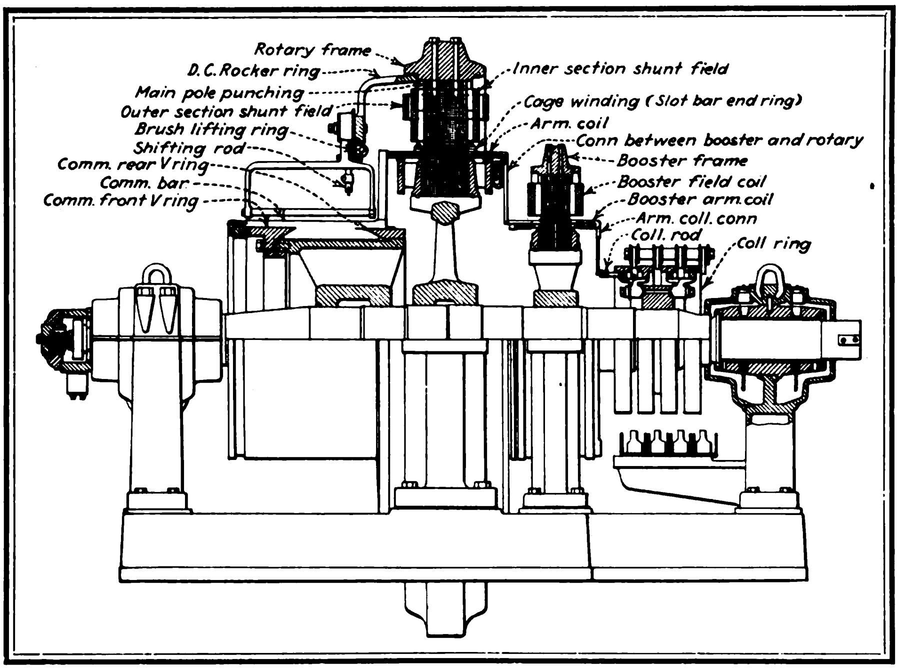


Fig. 10—Cross-section of a synchronous booster converter armature showing connections between the booster and the collector rings.

In this case the resistance leads connect to the coil at the rear end, pass through the armature slot and connect to the commutator at the rear end, as shown in Fig. 5*A*. A special clip is used to make the cross connection at the rear end also. The resistance leads are in the form of half-coils. In taking data, we start at the top and work down to the resistance leads. The result is shown in Fig. 5.

In Fig. 6 is shown another way of recording the bottom coil and resistance coil data for the armature shown in Fig. 5. This shows that the bottom coil in slot 7 lines up on both ends with the resistance leads in slot 7. The cross connection data are given in Fig. 5.

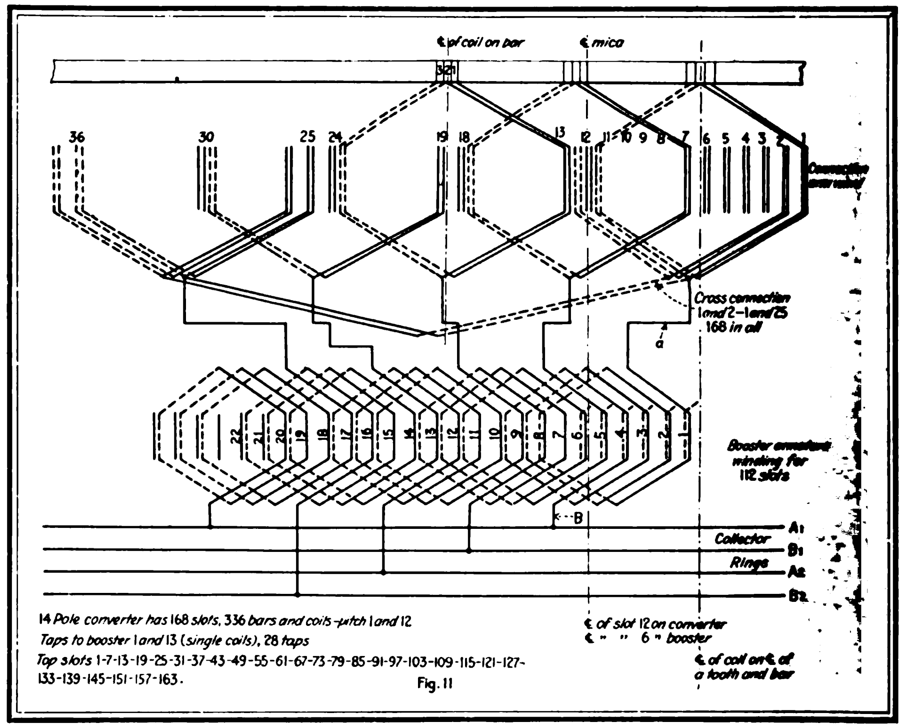
Rewinding data required for windings of rotary converter armatures will now be considered. In Fig. 7*A* a 250-hp., two-phase, 12-pole rotary converter armature with four collector rings is shown. In Fig. 7*B* is shown the rear end of an armature with the a.c. tap coils. Note the spacing and the method of bringing out the taps.

The rules that apply to collector ring connections apply also to ring-type equalizer connections: that is, there will be as many taps to each ring as there are pairs of poles. The spacing of the taps per ring, or pitch, is equal to $B \div P$. The total number of taps is equal to $P \times R$ or pairs of poles times number of rings. The tap spacing is $(B \div P) \times R$.

The majority of rotary converter armature windings are cross-connected and the a.c. taps tend to complicate the winding data. In some cases the collector rings and their taps to the winding are used as cross connections also. In other cases the spacing of the a.c. taps is different from the cross-connector spacing; therefore, care must be taken in recording these data.

In Fig. 7*A* the winding has 192 slots and bars, 4 rings, 12 poles, 6 taps to each ring. The ring tap pitch is $192 \div 6 = 32$, or 1-and-33 bars or slots. The total number of taps equals 6×4 or 24, and tap spacing is $192 \div 24 = 8$, or 1-and-9 bars or slots.

Fig. 11—Method of recording rewinding data for a rotary converter and booster winding.



In Fig. 1, one method is shown for recording winding data for a rotary armature, with the cross connections at the rear of the commutator. The winding in Fig. 1 is three-phase; therefore, there will be three rings and for ten poles there will be a total of 15 taps (five per ring) spaced as shown in the table with Fig. 1, which gives the data in bars and slots. This is necessary with more than one coil per cell windings, to enable the winder to space the coils. For instance, in winding the armature shown in Fig. 1 he would start with a tap coil; then put in eight plain coils; then a tap coil, and repeat.

Fig. 8 shows the data for an eight-pole, six-phase rotary with 144 slots and bars, coil pitch 1-and-18, and six collector rings. In this case the a.c. taps are also used as equalizer connections, resulting in 50 per cent equalization. That is, with six rings and eight poles, there will be 6×4 or 24 ring taps spaced as shown in the table in Fig. 8. The pitch is $144 \div 4 = 36$, or 1-and-37 bars; spacing equals $144 \div 24 = 6$, or 1-and-7. The ring layout is shown at the top of the data diagram. The machine also has a number of S-shaped involute cross connectors tapped into the rear of the winding, as indicated in the cross connection table in Fig. 8, making a total of $48 + 24 = 72$ taps. Fig. 8*A* shows one series of equal-

izer taps while Fig. 8 shows that there are two series of cross connection taps between the a.c. ring taps.

In Figs. 9*A*, 9*B* and 9*C* a method of recording data is shown for a machine similar to the one illustrated in Fig. 1; that is, one in which a flexible cable is used at the rear of the commutator for the equalizer connections. Fig. 9*C* shows the method of attaching the rings to the armature core and also the tap spacing. Note that rings *1*, *4*, *7* occupy the top row, rings *2*, *5*, *8* the middle row, and rings *3*, *6*, *9* the bottom layer.

Fig. 9*B* locates the equalizer taps and the a.c. collector ring taps in relation to the center line of the keyway, bar and slot. It also brings out the fact that the a.c. collector ring taps are used as equalizer connections. These taps are represented by dotted lines, making a total of 60 equalizer taps or 60÷360=16.6 per cent equalization; a spacing of 360 ÷60=6, or 1-and-7.

Fig. 9*A* gives the coil and tap data with reference to the keyway. This sketch also gives the tap coil spacing.

Taps for Booster and Converter Windings

There are 28 taps (7 to each ring) from booster winding to rings. Pitch 1-and-5, (1-and-17 for same phase).

Taps to ring A-1 in top of slots 4, 20, 36, 52, 68, 84, 100
Taps to ring B-1 in top of slots 8, 24, 40, 56, 72, 88, 104
Taps to ring A-2 in top of slots 12, 28, 44, 60, 76, 92, 108
Taps to ring B-2 in top of slots 16, 32, 48, 64, 80, 96, 112

Taps from Converter to Booster

Rear of Converter Winding to Front of Booster Winding

Ring No.	Converter Top Slot No.		Booster Top Slot No.	Remarks
A_1	1	to	1	Looking at machine from collector ring side, the strap is in the left-hand side of the slot connector to the booster; also the cross connector.
B_1	7	to	5	
A_2	13	to	9	
B_2	19	to	13	
A_1	25	to	17	There are 168 cross connectors—spacing is 1-and-3 and pitch in single coils is 1-and-25, as shown at rear of converter.
B_1	31	to	21	
A_2	37	to	25	
B_2	43	to	29	
A_1	49	to	33	On the booster armature slots *3, 7, 11, 15, 19, 23, 27, 31, 35, 39, 43, 47, 51, 55, 59, 63, 67, 71, 75, 79, 83, 87, 91, 99, 103, 107,* and *111*, 28 slots, are only half-full, i.e. contain only a top coil half.
B_1	55	to	37	
A_2	61	to	41	
B_2	67	to	45	
A_1	73	to	49	Front pitch on booster is 1-and-7. Rear pitch on booster is 1-and-8.
B_1	79	to	53	
A_2	85	to	57	
B_2	91	to	61	
A_1	97	to	65	Center line of keyway is on center line of slot *12* on converter, and center line of slot *6* on booster armature.
B_1	103	to	69	
A_2	109	to	73	
B_2	115	to	77	
A_1	121	to	81	
B_1	127	to	85	
A_2	133	to	89	
B_2	139	to	93	
A_1	145	to	97	
B_1	151	to	101	
A_2	157	to	105	
B_2	163	to	109	

From the examples just given of rotary armature windings, a check should be made to determine the relation between the a.c. collector ring taps and the equalizer connections and the information recorded in a manner that will enable any winder to rewind the armature and duplicate the original winding in every respect, including the spacing of taps with relation to keyway, a.c. and equalizer taps.

There is another type of machine that has a somewhat more complicated winding. This is the synchronous booster converter. In this type a synchronous, alternating-current generator or booster is added between the converter armature and the a.c. collector rings. In general the booster has the appearance of the ordinary direct-current generator; that is, there is a stationary field and a revolving armature, with distributed winding but without a commutator. A brief explanation of the function of this booster will help to give an idea what effect wrong data would have on the operation of the machine.

The booster main poles are in line with the converter main poles. This enables the booster winding to give an equal boost or buck with a given field excitation. Then by varying the field excitation of the booster, its armature voltage, which is alternating in character, may be increased or decreased and its voltage can be added to (boost) the d.c. voltage or it can be subtracted from (buck) the d.c. voltage. The voltage variation generally runs between 30 volts below normal to 30 volts above normal line voltage.

In Fig. 10 is shown a cross section of a synchronous booster converter

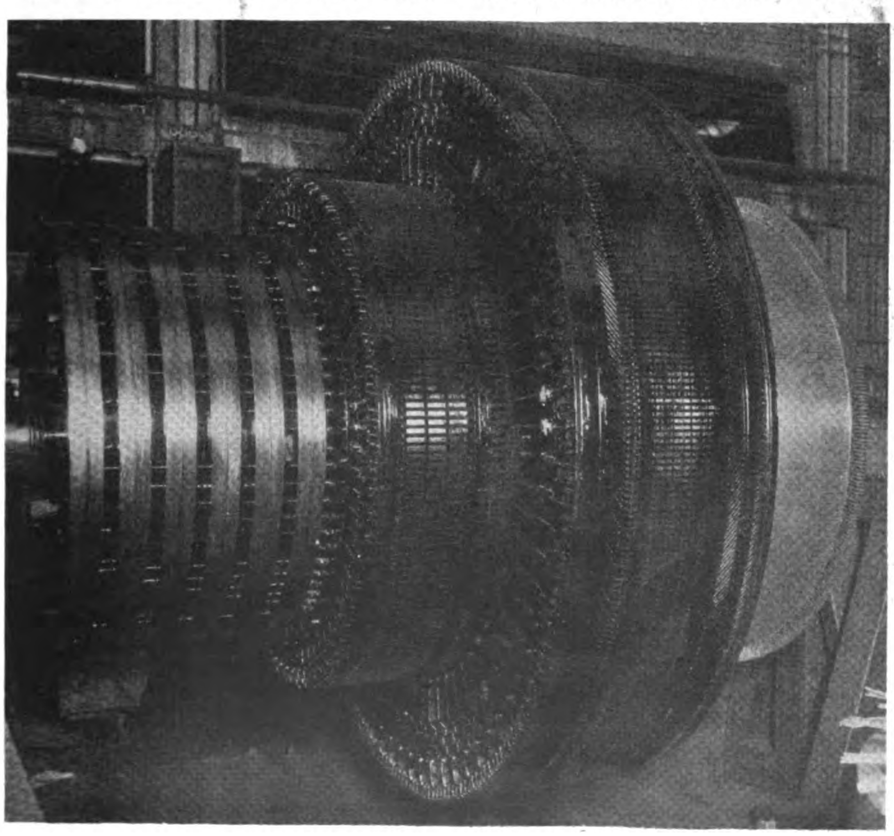


Fig. 12—This shows the complete synchronous booster converter of the type from which data were taken in Fig. 11. Note the taps between the rotary and booster windings.

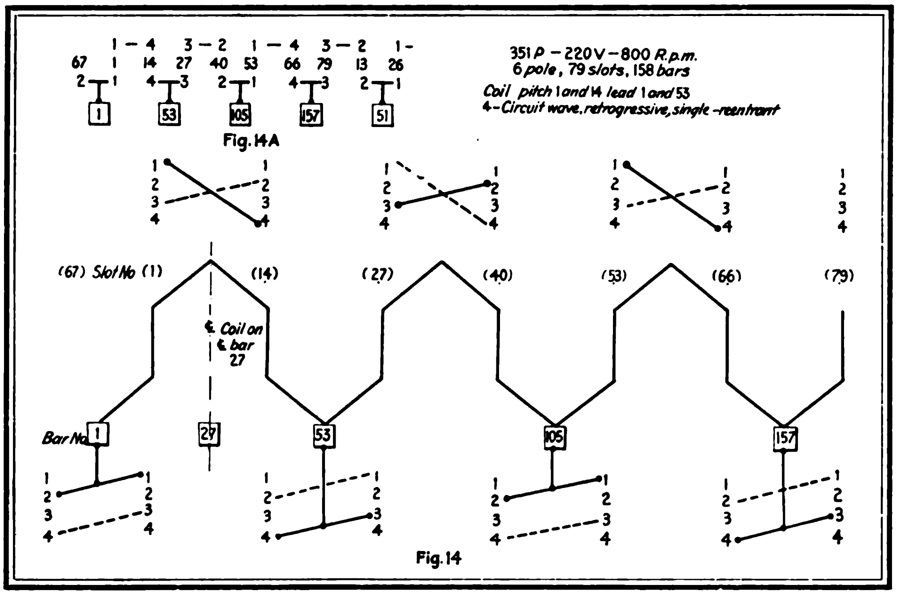


Fig. 14—Here is a simple form for recording data on the winding shown in Fig. 13.

This winding is for a 35-hp., 220-volt, six-pole, 800-r.p.m. motor with 79 slots and 158 bars.

armature, the booster armature, and the connection between the booster and the four collector rings. The taps from the rotary armature to the booster armature can be considered the same, and the same winding rules apply as to a.c. collector ring taps.

Fig. 11 shows a method of recording the rewinding data. Starting with the rotary armature winding which has 168 slots, 336 bars, 14 poles, 28 taps, and 168 cross connections, the equalizer pitch in slots is 168÷7=24, or 1-and-25. The spacing in slots is 1-and-2. In bars the equalizer pitch equals 336÷7=48, or 1-and-49, and the spacing is 336÷168=2, or 1-and-3. The coil pitch is 1-and-12, the tap spacing in slots is 168÷28=6, or 1-and-7, and the ring pitch is 168÷7=24, or 1-and-25.

Note the manner of tying the booster winding with the rotary winding by lining out from slot *12* on the rotary to slot *6* on the booster. The center lines of these slots coincide, as will be noted.

By following the tap *a* from the top of rotary armature slot *1* to the top coil in slot *1* of the booster winding, we find the booster circuit is from slot *1* to bottom *8*, to top *2*, bottom *9*, top *3*, bottom *10*, top slot *4* and then out to the A_1 ring on tap *B*. Or, the conductors in the top of slots *1*, *2*, *3*, *4* and in the bottom of slots *8*, *9*, *10* are in series with the tap from the rotary winding and the A_1 ring. This series of coils forms a separate group, there being as many of these groups as there are rings times pairs of poles. Also note that there will be a number of slots that contain only one conductor. This slot will be one booster coil pitch ahead of the slot that contains the ring tap; that is, the booster coil pitch is 7 or 1-and-8 and the tap *B* to ring A_1 is from the top of slot *4*. Then 4+7=11, or slot *11* will not have a bottom conductor.

The taps from the booster winding to the collector rings follow the same rules as applied to rotary converter armature collector ring taps.

In the tabulated winding data given in the table on page 125 for the winding shown in Fig. 11, the ring number is given before the rotary slot number as this ties the winding to the rings through the booster. At the top of this tabulation are given the data for taps to rings at the rear end of the booster winding.

Fig. 12 shows a complete synchronous booster converter rotating element for a six-phase machine. The large armature with the commutator is the rotary winding; the small armature has the booster

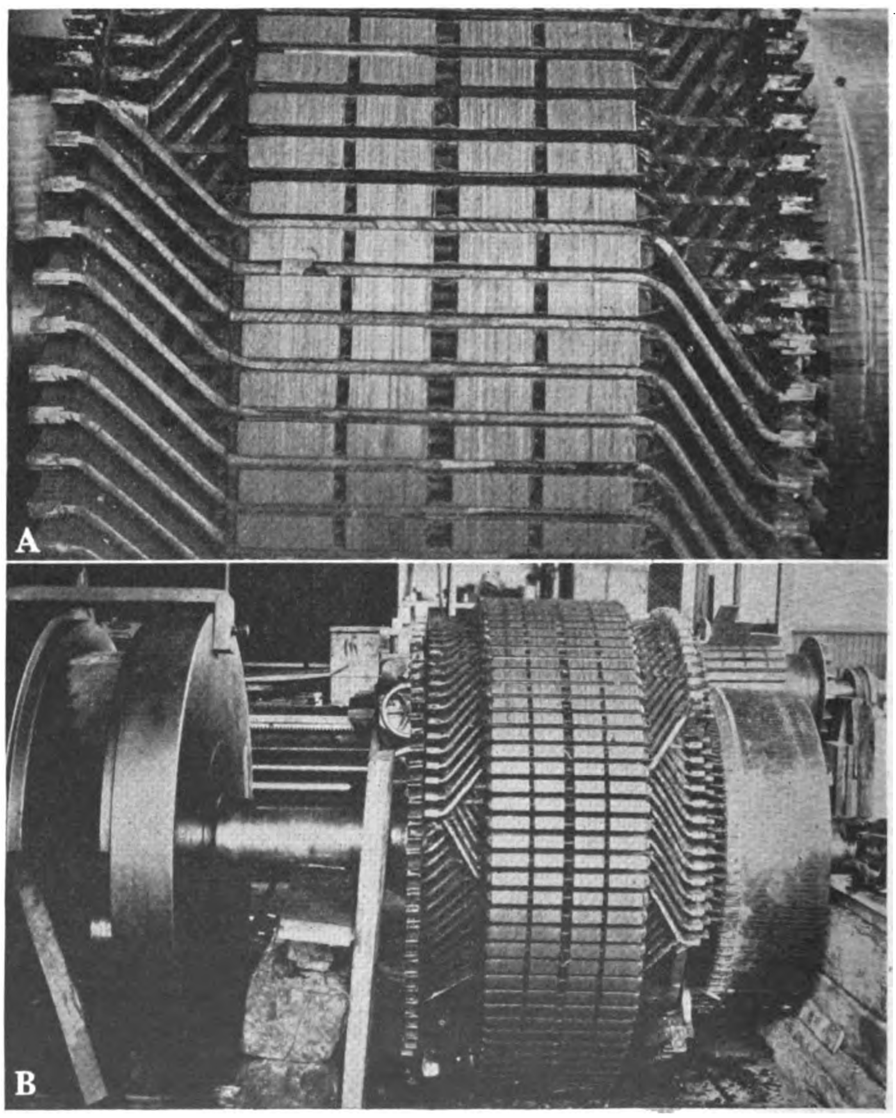


Fig. 13—This is a special duplex, six-pole, four-circuit wave, singly-reentrant, retrogressive winding.

winding. Note the taps between the rotary and booster windings.

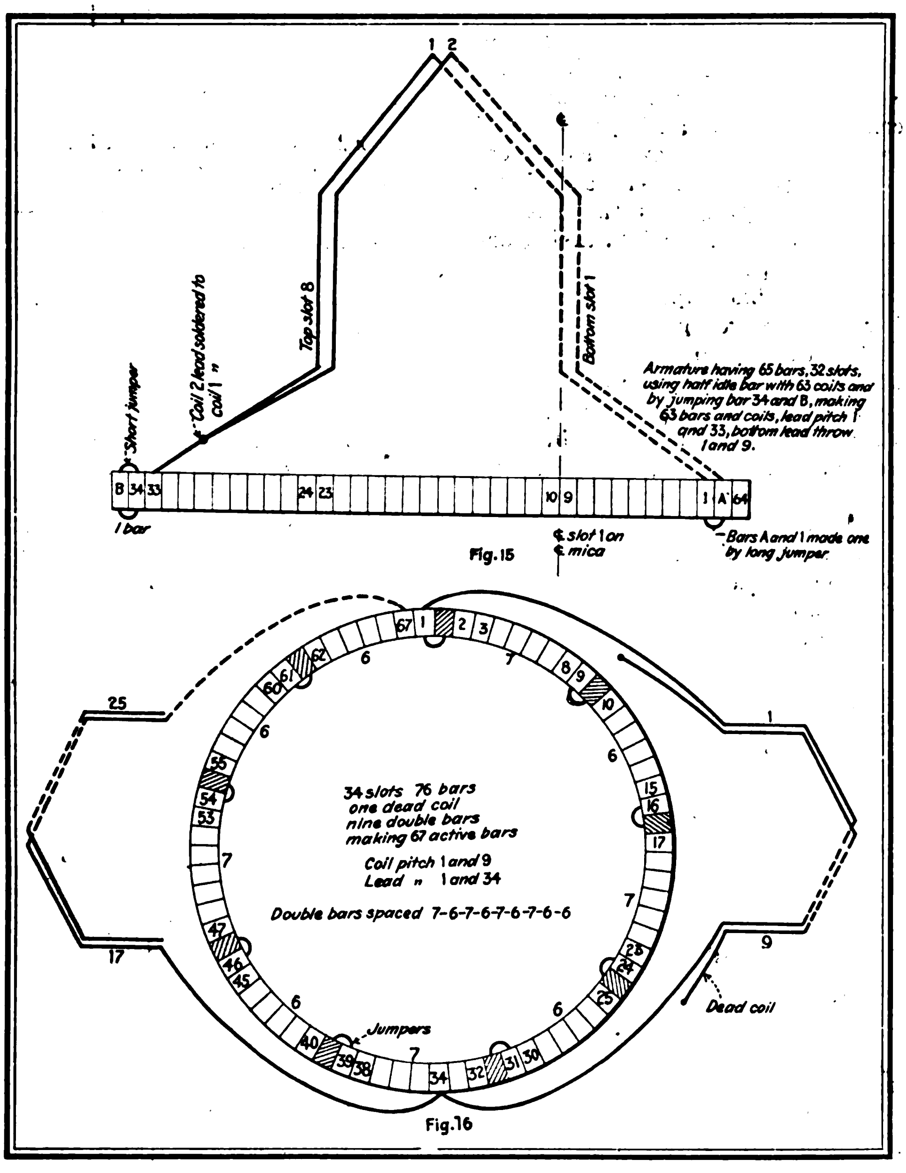
From the above it is obvious that too much stress can not be placed upon the importance of getting the proper relation between the booster and rotary armature windings. This can be done by locating the keyway, then the slots on a line with it, and then working back to a tap from the rotary to the booster.

In what follows information is given for a special duplex, six-pole, four-circuit wave, singly re-entrant, retrogressive winding. The top layer of conductors is shown in Fig. 13*A*, There are four conductors per slot, the top (No. 1) conductor being connected to a bottom conductor (No. 4) in a slot one coil pitch (13 slots) away by means of a special connecting clip. Conductors No. 2 and No. 3, in slots 1-and-13 apart, are connected together, the connection being made inside of the top and bottom connecting clip as shown in Fig. 13*A*, thus making two windings of the two-layer, diamond-shape type, one inside the other.

The armature is shown in Fig. 13*B* with the top layer of conductors removed. Note how the bottom conductor (No. 4) is connected across the front to conductor No. 3, and a connection made from their junction to the commutator. Also note that conductor No. 2 connects to conductor No. 1 across the front and a connection is made to the commutator from this junction, thus forming two layers of a two-layer winding at the front end. The start of the series of three coils can be traced around the armature in Fig. 13*B*.

Figs. 14 and 14*A* show the complete series. Starting at bar *1* (at the left in the diagram) which connects to the top conductor in slot *1*, we cross to slot *14*, conductor *4* or the bottom conductor across the

Figs. 15 and 16—Two types of windings that frequently give trouble to the winder.



rear, then from slot *14* conductor *4*, to bar *53*, to slot *27*, conductor *3*, across the rear of slot *40*, conductor *2*, then to bar *105*, to slot *53* conductor *1*, to slot *66*, conductor *4*, across the rear, then out to bar *157* which completes a series of three coils.

The data given in Fig. 14 are sufficient to lay off the winding but the data in the table furnish an interesting study of this type of winding.

In Fig. 15 are shown the winding data for an old type of motor that would give trouble to the average winder. This armature has 32 slots and 65 bars, and since there are only 2 times 32 or 64 single coils, there is one bar too many. The 64 bars will not connect into a single-series wave winding, but 63 bars will, since 63 plus 1 will give a lead pitch of 32, or 1-and-33. This means that by using a half-idle coil as shown, one bar will be used up and by jumping bars *B* and *34* and making them one, the number of active bars is reduced to 63.

Another odd type of winding is shown in Fig. 16. This armature has 34 slots and 76 bars or 9 bars too many, since there are 2×34=68 single coils and 68 bars will not form a single wave winding. Therefore, there will be one dead coil making use of a total of nine bars. These are used up in the manner shown in Fig. 16 by jumping bar *1* to the adjacent bar and considering these as one large bar. This is done at bars *9*, *16*, *24*, *31*, *39*, *46*, *54*, and *61*, which spaces the jumpers fairly even. In counting off the lead pitch or lead throw, the jumped bars must be counted as one bar. The series of two coils illustrates this fact.

On machines of any type that have interpoles, a careful check of the armature winding data should be made and particular attention paid to the alignment of the commutator bars with reference to the center line of the keyway when the commutators are removed for repairs, or when new mica segments are used.

When interpole machines are tested at the factory the end bracket and brush positions are located on the dead neutral. On machines having fixed brushes the end brackets are doweled to the frame, thus establishing a fixed position for the coil and lead pitch. The bars in the commutator also have a fixed relation to the keyway in the commutator bushing, that is, the center line of the bar or mica on the center line of the keyway and also the

center line of an armature tooth or slot, bears a fixed relation to the center line of the keyway in the armature punching. Also, both the keyways in the commutator bushing or spider and the armature punchings have a fixed relation, thus establishing a fixed relation between the center line of a coil, tooth, slot and bar or mica, according to the rules given above.

In dismantling a commutator and reassembling it without checking the relation of the bar to the keyway, there is a chance of throwing the neutral off. The greatest amount that the neutral can be shifted is equivalent to the chord of one-half the bar angle measured at the face diameter of the commutator or, in other words, one-half the width of one bar and one mica strip. The length of this chord or width of bar depends upon the number of bars and the diameter of the commutator, being greater with a small number of bars and a given diameter. That is, the chord length increases with a large diameter.

If a commutator has the center line of the keyway on the center line of a bar, then the most that the bar can be shifted would be to the position where the center line of the keyway lines up with the center line of the mica, which is a total shift of one-half bar. Changing the commutator alignment one-half bar, will affect the speed, causing a variation of 3 to 10 per cent in speed and also cause sparking and flashovers in some cases.

Figs. 17*A*, 17*B* and 17*C* show a tool or gage that has been developed to check the bar alignment with reference to the keyway. Fig. 17*A* shows a good view of the gage, which consists of two fixed arms at right angles to each other, the upright arm being attached to the shorter arm in such a manner that its inside surface is on the center line of a slot in the short arm. This slot carries a small dummy key that fits the keyway in the commutator bushing under test. The inside surface of the upright is thus on the center line of the keyway. This upright is slotted and carries an adjustable arm which is also slotted and has a pointer at one end. The surface of the adjustable arm that is in contact with the surface of the upright represents the center line of the keyway.

Fig. 17*B* shows the gage in place at the rear of a commutator and shows how the keyway center line is transmitted to the surface of the commutator.

Fig. 17*C* shows the top front view of Fig. 17*B*, which indicates that the center line of the keyway is on the center line of the bar.

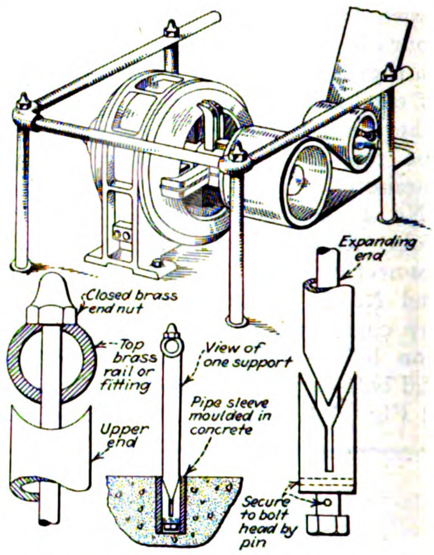
From the above it follows that, when taking rewinding data, the keyways of the armature and the commutator, play an important part in all cases (none excepted). The rewinding data should be laid out with the keyways as the base or starting point of the data taking and recording operation.

A little time expended when taking and recording rewinding data will in the end prove a time-, labor- and material-saving proposition.

When taking data on a machine with which one is not familiar, do not cut off any leads nor lift too many coils, without first marking the core and commutator and also making a pencil sketch to show the relation of the disturbed parts. In other words, make a lot of haste very slowly.

Rigid But Demountable Rail Around Machinery

SOME form of guardrail is often essential around steam engines, turbines, motor-generators, motors and other machinery to protect employees or visitors around the plant. A demountable guard rail, which may be used for this purpose, is shown in the accompanying sketch.



The advantages of a guard rail which can be removed easily are obtained in this construction.

A feature of this construction is that although this rail is rigid when erected it can be removed easily. Also, no flanges project above the floor when the guard rail is removed.

The rail is set into sockets which are made up of short pipe sections cast into the concrete. The uprights are made of brass pipe, with an expanding member of special construction. The horizontal top rail is held securely by the same bolt which holds the vertical supports fast in the floor sockets.

Washington, D. C. G. A. LUERS.

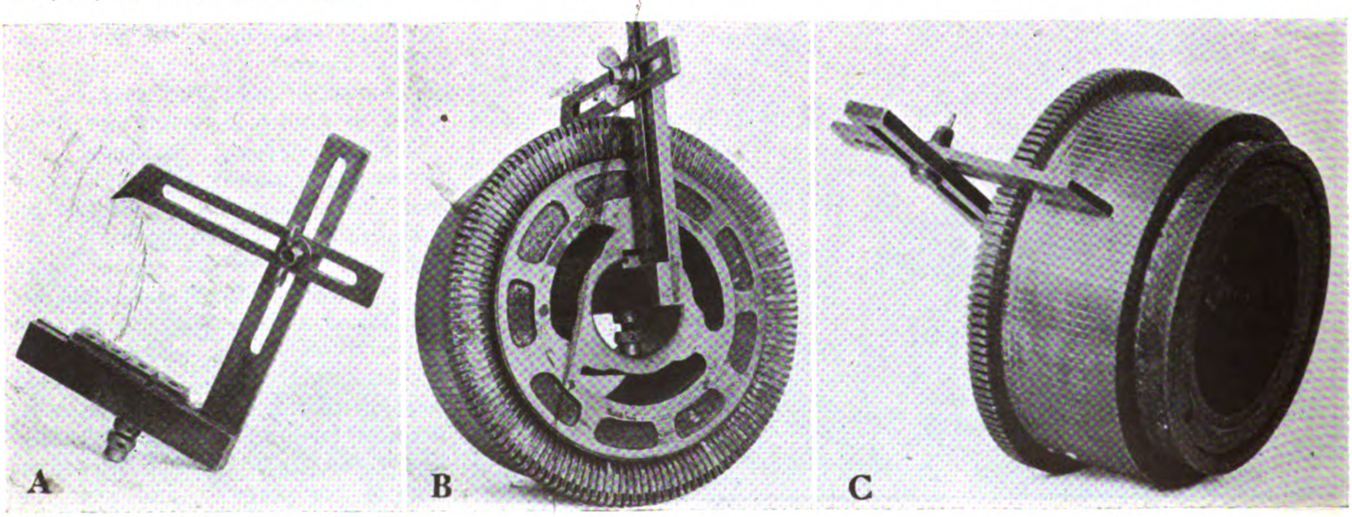


Fig. 17—This is a tool or gage that is useful in checking up bar alignment with reference to the keyway on a commutator spider.

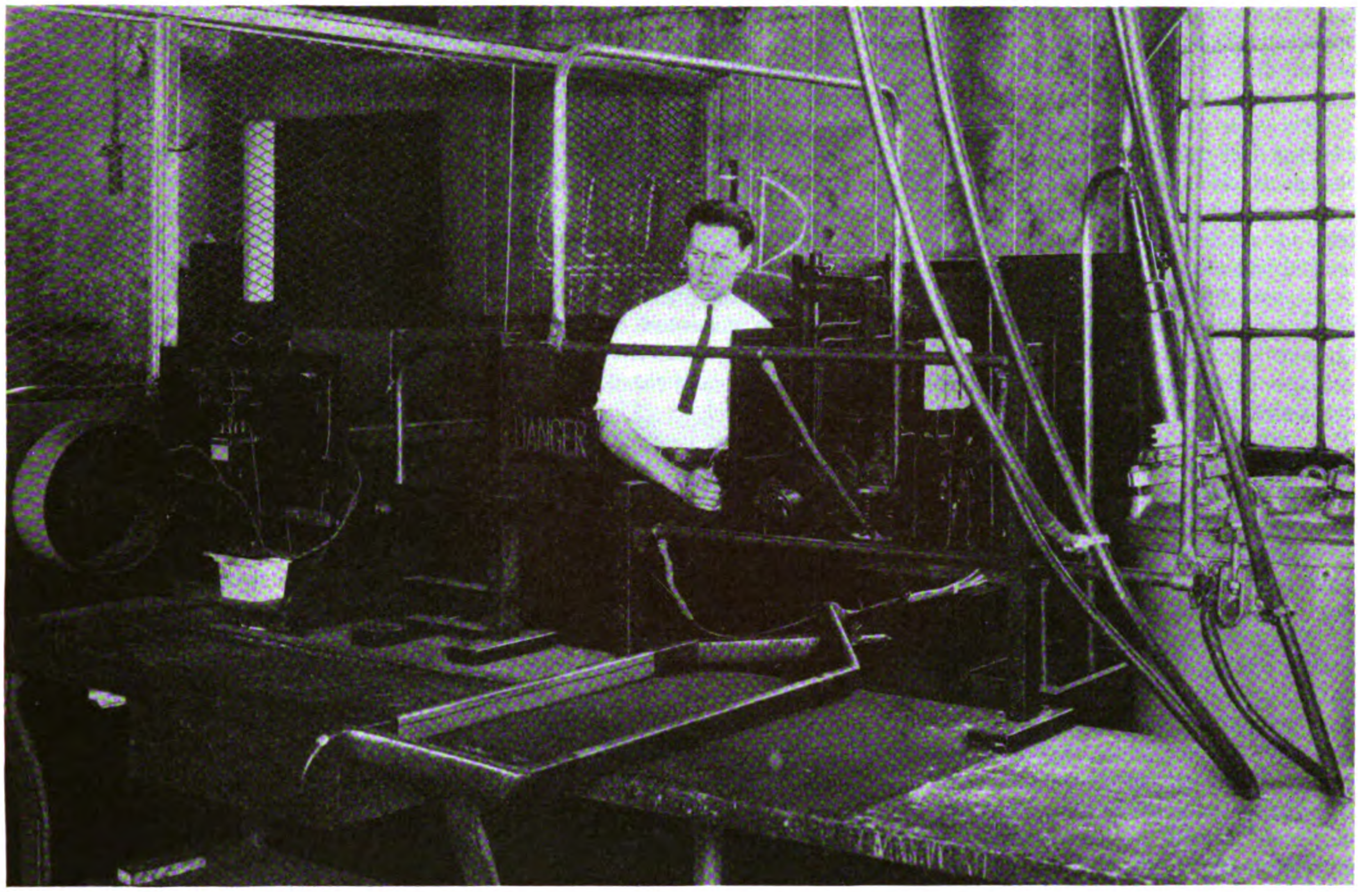


Fig. 1—A very high voltage can be applied to any winding without injurious current flow, if its frequency is sufficiently high.
The apparatus illustrated here provides high voltage having a frequency varying between 5,000 and 200,000 cycles per sec., depending upon the equipment under test.

Testing Insulation With High-Frequency Voltage

together with faults of present methods of testing and the scope of application and results obtained through the use of the new method

By J. L. RYLANDER
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INSULATION is used on rotating electrical apparatus to insulate between the various parts which have a difference of potential and also to insulate all parts of the circuit from "ground." The "ground" insulation is thoroughly tested by the present method of applying a high potential, usually at normal frequency, between the winding and the core or frame at various stages of construction. The present methods of testing the insulation of various parts of the same circuit, such as from one turn to other turns, or one layer of wire to other layers of wire, are far from adequate.

The present method of testing consists of placing the coil over a pole piece magnetized by a primary coil which induces a voltage in this coil as the secondary coil of a transformer. The maximum voltage that can be induced by this method will not exceed 10 or 20 volts per turn in most coils, as the voltage is limited by the size of pole piece that can be inserted into the opening of the coil and by the frequency of the circuit. Usually 133 or 500 cycles per second are used. This test discovers short-circuits where there is actual copper-to-copper contact. However, it does not discover any weak or damaged insulation where there is not actual copper contact. Therefore, many coils are given no insulation test.

> FOR MANY years the need for a higher test voltage between turns of individual coils or complete windings has been recognized. To obtain this higher test voltage, high frequency is now being used. How the high-frequency voltage is generated, applied to the apparatus under test, and the benefits obtained through its use are discussed in this article, which is an abstract of a paper delivered by Mr. Rylander at the Midwinter Convention of the American Institute of Electrical Engineers held last month in New York.

The windings of d.c. armatures are tested by this same induction method by revolving the armature slowly and testing each coil separately. This test discovers any short-circuits caused by actual copper-to-copper contact and also discovers open circuits. As this type of testing apparatus is only adaptable for rotating windings, induction motor primary windings are not given this test.

In order to obtain a higher test voltage, that would be considered a real insulation test, between turns of coils both before and after winding the coils in the machine, high-frequency voltage is applied directly to the terminals of the coil or windings.

With high frequency, advantage can be taken of the inductance of the coil or winding and thus obtain almost any voltage desired.

The use of high frequency for various test purposes is not new, but as far as the author is aware it has not been applied to the commercial testing of individual coils and of wound apparatus.

A very high voltage can be applied to any winding if the frequency is sufficiently high. The voltage drop due to the inductive reactance is $E = 2 \times 3.1416 \times f \times L \times I$, where f is the frequency in cycles per second, L is the inductance in henries, and I is the current in amperes. For example, a 15-turn circular coil with a 12-in. diameter having a d.c. resistance of 0.1 ohm and an inductance of 0.001 henry would have approximately the following voltages across its terminals with 10 amp. in the circuit: 1 volt, d.c.; 4 volts, 60 cycles per second, and 4,000 volts with 60,000 cycles per second. It is thus seen that practically any desired voltage can be placed across a coil or a winding if sufficiently high frequency is applied. The voltage is applied by connecting the two leads from the high frequency apparatus directly to the terminals of the coil or winding, either partially or completely finished.

When high frequency is applied to the apparatus under test, it sets up an alternating electromagnetic field of a particular frequency in a manner similar to a radio transmitter. If a short-circuit occurs in the winding, the wave length and frequency will be changed accordingly, and the strength of the outgoing signals is reduced. A wave meter is used to measure the outgoing waves and thereby determine whether any insulation failure has occurred.

The wave meter consists of a set of inductance coils, variable condenser with a vernier attachment, two variable resistances and a low-reading ammeter of the thermo-element type, all connected in series with one of the inductance coils. The inductance coils are such that by changing the setting of the variable condenser, resonance may be obtained for the frequency generated by the coil or winding under test. The condenser, the ammeter, and the variable resistances are mounted on a panel and a tuning coil is placed near the apparatus being tested. The tuning coils have low resistance and a minimum capacity for a given inductance. Coils with taps are unsatisfactory on account of the end-turn loss.

The wave meter is tuned to the frequency of the waves emitted by the apparatus under test and it acts in a manner similar to a radio receiving set. A current flows in the wave meter circuit which is measured by the ammeter. The variable condenser is adjusted until a maximum current is shown on the meter which thereby indicates the condition of resonance and also the frequency of the circuit. The meter reading alone does not mean anything in particular; it is the relative meter readings used in connection with the condenser readings and the distance from the tuning coil to the apparatus under test which tell the story.

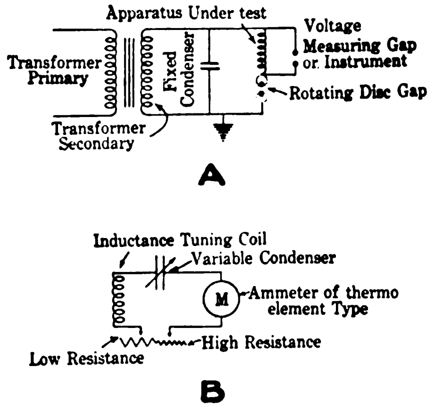


Fig. 2—The connection scheme for the equipment producing high voltage is shown at A.

Diagram *B* shows the connections for the apparatus used to detect the presence of short-circuits or other defects in the winding under test.

The principle by which high frequency is produced by this outfit is that a condenser placed across the secondary terminals of the transformer is charged during each alternation of the 60-cycle current. The condenser is automatically discharged through rotating disks when the voltage reaches a predetermined value on each alternation. The discharge of the condenser through the apparatus under test produces a high-frequency current whose frequency is determined by the apparatus under test and the capacity of the condenser.

The high-frequency testing apparatus for commercial use consists essentially of, (1) equipment for generating the high frequency and applying it to the apparatus under test, and (2) a means of detecting any short-circuits or failures in the insulation of the apparatus under test while the high frequency is being applied. An illustration of the apparatus is shown in Fig. 1. A schematic diagram of the connections is given at *A* and *B* of Fig. 2, Fig. 2*A* showing the generation of the high frequency and its application to the coil or winding and Fig. 2*B* showing the apparatus used in the detection of an insulation failure.

The power is furnished by a transformer of 10-kw. capacity with 7,500/15,000 and 30,000 volts on the secondary. A 70 per cent reactance limits the current to one and a third times full-load current with the short-circuit current in the secondary. The condensers have a capacity of 0.05 microfarads at 30,000 volts. The air-gap for discharging the condenser is formed between two motor-driven, rotating, brass alloy disks so that the arc across the gap will not burn the metal. The sphere-gap limits and measures the voltage across the apparatus under test. A resistance of 15,000 ohms is placed in series with the sphere-gap to prevent the spheres from being burned by the arc. For voltages of 5,000 and higher, 5-cm. spheres are used, and for lower voltages 1-cm. spheres are used, also instrument measurement. A panel contains switches for the circuit breaker and plugs for tapping in different values of reactance. A handwheel is used for controlling the spacing of the gap of the rotating disks. Voltages ranging from 2,000 to 30,000 volts can be obtained with this particular apparatus. By a combination of series and parallel connections the transformer will give 7,500, 15,000 or 30,000 volts; intermediate voltages are obtained by adjustment of the rotating gap.

The manipulation of the test apparatus consists of connecting the leads to the coil or winding under test and setting the sphere gap for the value corresponding to the desired test; then closing the circuit breaker and opening up the rotating disk gap until the desired voltage is obtained. This is indicated by a spark across the measuring gap. The voltages are generally applied for 10 to 15 sec. The frequency is determined by the apparatus under test usually within the limits of 10,000 to 200,000 cycles per sec. for individual coils and 5,000 to 100,000 cycles per sec. for wound apparatus.

The damped, high-frequency voltage as produced by this set gives a somewhat more severe test on the insulation than a corresponding

voltage at normal frequency. Fortunately such a test can be used to discover faults without damage to the normal insulation.

In general, the voltage builds up somewhat on the end coils. At first thought this may seem to be a disadvantage, but in actual service the end coils of a group are subjected to greater voltage in the case of surges than are the other coils. The voltage on the inner coils is sufficiently high, however, to give an adequate test for defects in material or workmanship.

The high-frequency, test voltage applied to the terminals of wound apparatus corresponds closely to the regular ground test as given by the Standards of the American Institute of Electrical Engineers. This allows a liberal margin of safety over the strain due to operation at its normal voltage, and also to the momentary high-voltage, high-frequency surges that may be impressed in service.

The voltage which it is desirable to apply to individual coils before winding into a machine is largely a question of judgment based on experience. We have used successfully on induction regulator coils a test voltage on single coils somewhat higher than the operating voltage of the machine for voltages lower than 2,500 volts, while for voltages over 2,500 a test voltage somewhat lower than the operating voltage was used.

The methods used for various types of apparatus are somewhat different, depending on various conditions. The method of testing a single coil is shown in Fig. 1.

The method of testing the windings of a two-pole, single-phase induction regulator is shown diagrammatically at *I* of Fig. 3 for the stator and at *II* for the rotor. The two leads from the high-frequency set are connected to leads *A* and *B* of one pole and the tuning coil of the wave meter is placed alongside the frame as shown at *C*. The voltage is applied for 10 to 15 sec. The two high-frequency leads are then connected to the leads *E* and *F* of the other pole of the winding and the tuning coil placed at *G*.

The high frequency leads can be connected to three-phase machines by the methods shown at *III* to *VI* of Fig. 3. The high-frequency leads may be connected across each pole-phase group as shown at *V*, from each lead to the star connection, as illustrated at *VI*, or across the leads, as at *III* and *IV*. Each of these connections has merits for certain conditions as determined by the number of poles, the voltage of the machine, the number of turns in the winding, the number of parallel connections and the size of the machine.

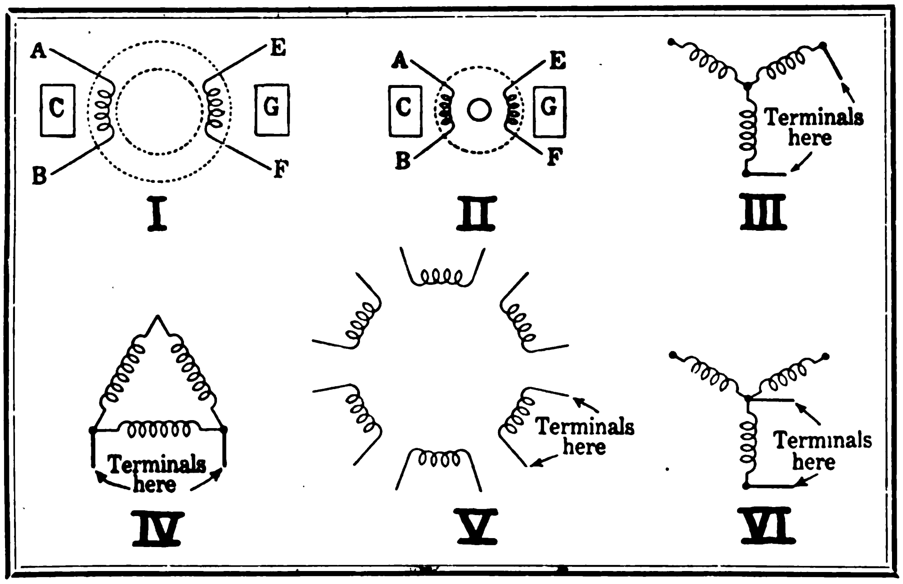
On a d.c. armature the voltage is applied at two points on the commutator corresponding to the location of the brushes, and the armature is then rotated.

The tuning coil of the wave meter is placed in the most advantageous position, which usually is close to the outside circumference of rotors and either inside the bore or outside the frame of stators.

For each coil and winding the wave meter settings are recorded.

Fig. 3—Methods of applying the high-frequency voltage to various types of windings.

Diagrams *I* and *II* show the method of testing the stator and rotor of a single-phase induction regulator. Diagrams *III* to *VI* inclusive, show the testing methods for three-phase induction regulators having various connection schemes.



These settings show both the frequency and the strength of signal transmitted from any particular apparatus when the winding is normal and free from faults. As each coil or winding is tested, the readings will correspond to the standard readings if the winding is free from faults, but if short-circuited, different readings will be obtained. It is thus easy to check any apparatus that has been previously tested. If new, the approximate readings can usually be estimated with sufficient accuracy by comparing the general characteristics of the windings with other known windings, and checking one part of the winding with another is an additional check. The fact that a short-circuit has a deadening effect on the radiations transmitted as well as changing the wave front length and frequency, facilitates the discovery of any short-circuits.

This method of insulation testing was first applied commercially in the testing of induction regulator coils. The results were so satisfactory that the test was extended to the wound regulators, both stators and rotors of single-phase and three-phase machines of all voltages up to 14,000 volts and hundreds of wound primaries and wound secondaries are now being tested each month with high frequency. The development has now reached a point where completely wound d.c. armatures, turbo-generator coils, and wound induction motors either partly or completely connected have been tested experimentally. Considerable experimental work must be done before this method can be applied safely as a commercial shop test to complete windings of large alternators or induction motors. For example, sufficient information as to satisfactory test values is not yet available to apply high-frequency voltage, as a test to the complete windings, which will be a proper measure of their ability to withstand surges during operation.

Testing coils and windings with high frequency has given valuable information on the insulation of the apparatus to which this test is applied. For example, it has shown that insufficient insulation for reliable operation was used in some cases; that different kinds of material should have been used in others; that certain insulating materials have been badly crushed during one of the coil-forming operations; that the vacuum impregnation has not fully penetrated to all parts

of the coil, and that the moisture has collected in these spots; and that the insulation used on certain designs was too liberal. It has also furnished a good idea as to whether the insulation was sufficiently balanced between the various turns and layers to withstand the natural uneven voltage distribution that occurs in coils and windings whenever the windings are subjected to surges and line disturbances.

Consequently, it is seen that high-frequency testing has made possible the improvement of the insulation of the windings by eliminating weak or defective coils, which might otherwise have been used. High frequency also checks the ability of the insulation to withstand the occasional severe dielectric strains that will occur in service and to which at present so many of the otherwise unaccountable insulation failures are attributed.

As induction regulator coils have been tested regularly for over four years some of the results of these tests will be of interest. During the first two years, 5 per cent of all coils tested failed to stand the prescribed test but the weekly percentage of failure varied from 1 per cent to 30 per cent. During the past year the percentage failures varied from 0 to 2 per cent weekly, with an average of 1 per cent. This great reduction in the number of coils that failed to stand the test was accomplished by correcting the cause of the trouble, which can usually be determined by a thorough, painstaking examination.

However, if these coils had not been rejected on account of the high-frequency test, all of the coils would otherwise have been used, as none of the coils had any defect that could have been discovered by any other method than the use of high-frequency voltage testing.

A record of the complete windings that have been tested shows that out of 100 machines of a certain particular type there were no failures, but on other types there were as high as 10 per cent and an average of 1 per cent for all types. It is not to be inferred that the faults detected by this test would all have resulted in service failures. The applied test has purposely been made severe in order to certainly weed out all weaknesses of this class.

There has been a distinct improvement in these machines from the service standpoint. Whereas, there was a considerable number of failures, before high-frequency testing was started on these coils, there has not been reported a single insulation breakdown in service of any machine on which the high-frequency test had been applied to the coils or the winding.

High-frequency testing shows up poor workmanship, checks the insulation design and the processes of manufacture. It insures that proper and adequate insulating materials are in their proper place and not missing or damaged and that no harmful foreign materials are present therein.

It checks up such features as the elimination of moisture and the thoroughness of impregnation, undue mechanical pressure at any point and the ability of the materials to stand the mechanical operations of coil construction, and whether the various materials are sufficiently uniform.

All of the above conditions may exist but they may not be detected or discovered without the aid of high-frequency testing as they are hidden from view and consequently visual inspection does not reveal any imperfections.

One real merit of high-frequency testing is that it invariably shows the cause of the failure, as the arc is of only such intensity as to burn out the weak insulation without burning the copper. When a machine fails in service the opposite nearly always occurs, as the copper is usually so badly burned as to destroy all evidence of the cause of the insulation failures.

Comments on "Compensators and Primary Resistance Starters"

I HAVE been much interested in the symposium discussion on "Operating Characteristics of Compensators and Primary Resistance Starters" for starting squirrel cage motors, which appeared in the January issue of INDUSTRIAL ENGINEER. It is very easy to argue in favor of either compensator or resistance starter from the standpoint of electrical characteristics, and each has certain legitimate, although more or less theoretical, advantages which can be claimed for it.

However, a point which has been overlooked by all but one contributor, and barely suggested by him, is the reliability of the apparatus and the ease with which it may be placed in service again after a breakdown, by either temporary or permanent repairs.

In this respect primary resistance starters, whether of the so-called "compression" type, the grid type or the wire or ribbon wound type, possess a considerable advantage over the compensator, particularly where continuity of service and reduction of length of shutdowns are important.

Compensator coils do burn out more or less frequently from various causes, as the writer has learned from sad experience. About the only way to repair a burned-out compensator coil is either to rewind it, material and labor for which are seldom at hand, or to replace it with a new coil, which usually must be obtained from the manufacturer's warehouse and often from his factory. Any of these procedures involves a delay of from several hours to several weeks, as I likewise have cause to know.

Resistance starters, on the other hand, not only very seldom burn out (any failure being usually due to mechanical damage), but if the resistance unit does open it is a comparatively simple matter to patch it until new parts can be obtained. If cast grids are used they can be wired or clamped together; if a wound resistor burns open, repairs can usually be made by bridging the break, while there are several methods available for repairing the carbon disk type. Any of these repairs can be made in from a few minutes to a few hours at the most. The cost is correspondingly small.

Often continuity of service outweighs the small difference in efficiency which may exist between the two general types of starters.

LOUIS D. MOORE.
Formerly Electrical Engineer, Missouri Pacific Railroad Co., Kirkwood, Mo.

* * * *

I have read with considerable interest the article concerning the operating characteristics of compensators and primary resistance starters that appeared in the Janu-

Comparative Data on Starters for a 10-Hp., 220-Volt, Squirrel-Cage Motor

	Using 67 per cent of Line Voltage for Starting		Using 80 per cent of Line Voltage for Starting except in case of Across-the-Line Starter		
Class No. of starter	8605	8547	8605	8547	
Type of starter	Compensator	Primary Resistor	Compensator	Primary Resistor	Across-the-Line
Full-load current	29	29	29	29	29
Current inrush at line voltage	174	174	174	174	174
Starting voltage—per cent of line voltage	67	67	80	80	100
Starting torque—per cent of full-load torque	78	78	112	112	175
Line current at start—amp.	78	116	111	139	174
Size of starting fuses—amp.	60	90	90	110	150
Size of conductor required	No. 6	No. 4	No. 4	No. 2	No. 1

ary issue of INDUSTRIAL ENGINEER.

The difference between the two types of starters is very clearly brought out, but there is one point in regard to their practical application that has not been mentioned. With the primary resistance starter, it is usually necessary to provide heavier conductors for the supply circuit, and install larger fuses to take care of the greater current required in starting. This point can best be illustrated by comparing an I-C Class 8605 automatic compensator with an I-C Class 8547 primary-resistance type automatic starter. The comparative sizes are shown in the accompanying table which has been made up for a motor rating of 10 hp., 220 volts, three phase, 60 cycles.

Data are given for a starting voltage of 67 per cent of line voltage, in the first two columns of the table, and for a starting voltage of 80 per cent of line voltage in the next two columns.

With regard to the starting voltage in ordinary use I believe that the 67 per cent tap on compensators is satisfactory for over 90 per cent of ordinary applications. It is the practice of the Industrial Controller Company to connect all compensators on the 67 per cent tap for standard use, and it is very seldom that we ever hear of the necessity for changing to a higher voltage.

It is true that, if the comparison is made on the basis of 80 per cent of line voltage for starting, there will be less difference between the compensator and the resistance starter, although even in this case the current drawn from the line would be 25 per cent greater in the case of the resistance starter. Under these conditions, however, neither starter would meet the usual power company requirements as to allowable starting current, which places them on an equal basis.

From a practical standpoint it would seem that when the operating conditions are such that a motor will not start until 80 or 85 per cent of line voltage is applied to the motor terminals, the compensator or resistance starter might almost as well be discarded and the motor thrown directly across the line. As a matter of interest, however, it might be worth while to make a comparison showing fuse and conductor sizes for the two types of starters connected on the 80 per cent taps, comparing these also with a starter of the across-the-line type. This comparison is drawn in the last three columns of the accompanying table.

So far as the user is concerned, the most important factor to consider in determining which type of controller is to be used is the question of torque required and the line current permitted by the power company. After this point is decided the most important consideration is the mechanical design of the controller itself, as either type of starter will, of course, operate satisfactorily. We believe that, from a practical standpoint, the questions as to line voltage disturbance, power factor during starting, and power loss in starting, can be disregarded.

There is, however, one application where the transformer type of starter has the advantage over the primary resistance type, due to less power loss in starting. This is where the starter must be made dust tight and where ventilation is not practicable. The losses in the transformer are so small that no difficulty is experienced with dust-tight enclosures, but with the resistance type starter some ventilation is usually necessary in order to dissipate the heat developed.

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Specifications for Lubricants

(Continued from page 117)

this year or next, that brand will have the same viscosity, flash and fire, specific gravity, cold test and other tests. Specifications are the oil refiner's guide in standardizing the production of his plant so that he can produce, year after year, the oils that he has found to be successful in meeting conditions in actual operation. They are the oil refiner's insurance that his product is of a certain quality and has certain characteristics.

Oil specifications mean much to the refiner of lubricating oils. Service is the specification that means much to the user of lubricating oil. Practically all manufacturers of lubricants have made a close study of the problems of lubrication in industry and are equipped to offer service and advice, which is based on a wide experience with industrial operating conditions, in the choice and application of lubricants to the particular problems of a plant.

Purchasers and users of oils in industrial plants would do well to acquaint themselves with the various specifications and the tests that are made in order to determine those specifications, if for no other reason than to be able to give them their proper weight, and no more, when they are buying lubricants, or making recommendations, or endorsing recommendations to solve the lubrication problems of their machinery or equipment.

A discussion of the various types of equipment and devices for applying lubricants under different industrial operating conditions will be taken up in another article of this series to appear in an early issue of INDUSTRIAL ENGINEER.

EDITOR'S NOTE: Special acknowledgment is made to the Vacuum Oil Co., New York City, for valuable information and assistance in the preparation of this and previous articles. Other companies who have co-operated are: Dearborn Chemical Co., Chicago, Ill.; Jos. Dixon Crucible Co., Jersey City, N. J.; Keystone Lubricating Co., Philadelphia, Pa.; Marland Refining Co., Ponca City, Okla.; The Pennzoil Co., Oil City, Pa.; Riehle Bros. Testing Machine Co., Philadelphia, Pa. (oil and bearing testing apparatus); Standard Oil Co. of Ind., Chicago, Ill.; Superior Flake Graphite Co., Chicago, Ill.; C. J. Tagliabue Mfg. Co., Brooklyn, N. Y. (oil testing apparatus); The Texas Co., New York City; Waverly Oil Works Co., Pittsburgh, Pa.

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

G. A. VAN BRUNT, *Managing Editor*

If You Show Appreciation for Good Work You Will Get More of It

RECENTLY an executive who has made an unusually rapid advancement from the ranks to the Vice-Presidency of an internationally-known institution was introduced at a dinner by one of his former superiors with the remark, "One of his outstanding characteristics is his practice of always giving the other fellow credit when he has done a good job." He might have added that this practice has unquestionably been an important factor in the success of many an executive.

Appreciation may be defined as a just valuation or proper estimate of worth or merit. It does not necessarily signify payment of money for services rendered. The reward may only be a handshake or a word of praise, but its value to the recipient is usually out of all proportion to its cost.

It is not an easy matter for anyone to do his best, month in and month out, and for most of us it is particularly difficult to keep up the necessary interest and sustained effort when there is a feeling that no one knows or cares whether we are doing our best.

Most successful executives have learned that a few words of appreciation for work well done are exceedingly effective in securing results in the way of loyalty and efficient service, that would be difficult or impossible to obtain by any other means.

Do Not Overlook the Valuable By-products of Maintenance Work

MOST of the benefits that accrue from proper maintenance attention to equipment are well known. Some of the incidental benefits, by-products, as it were, may not be so apparent or well recognized. On this point two of the maintenance executives who discussed their problems in the February, 1926, issue of INDUSTRIAL ENGINEER made interesting comments. For example, Hugo Slivinski, Master Mechanic, Deering Works, International Harvester Co., said:

> Whenever a machine is taken down and repaired or overhauled, it is always given a coat of paint. This freshens up the machine and the operator looks on it more as he would a new machine and so gives it better treatment.

Again, W. W. Lankton, Asst. Electrical Engineer, Detroit Copper and Brass Rolling Mills, had this to say:

> The curve drawing meter also has a peculiar psychological effect. Whenever it is being set up on a motor-driven machine, the operator almost invariably goes over his machine very carefully, oiling all parts and looking over belts and pulleys. In some cases of overloads, the trouble is immediately rectified in this manner.

Even though it is oftentimes necessary to make operators responsible for oiling and otherwise taking care of their machines, it can be assumed that in many cases these men are not particularly interested in this part of their work. This indifference, combined with more or less ignorance, is likely to result in neglect of the equipment, in the absence of some outside stimulus. The management must supply this stimulus and can do it most effectively through the medium of a well-organized maintenance department. If the plant owners or management do not care enough about the equipment to take the proper care of it, operators can hardly be blamed for adopting this same attitude and neglecting their machines. Neglected equipment spells low output, poor quality of work and, usually, low wages, all of which make for low morale.

The work that the maintenance department does in keeping the wheels turning is worth all it costs, and more. In addition, the by-products alone of this work merit all of the support and encouragement that you can give to the maintenance department.

What "Rating" Means and How It Should Be Considered

MISUNDERSTANDING of how to use properly the manufacturer's rating of equipment is often one of the important causes of dissatisfaction with the service rendered. Ordinarily the general or nominal ratings as listed by the manufacturer are intended only as a general guide, and are not always suitable for promiscuous selection and application. However, the prospective user needs a guide to indicate the various sizes of units available. As a general rule, the manufacturer rates his equipment at the highest safe figure obtainable under practically ideal operating conditions. Service or operating factors are then set up by which the rating is multiplied to give a new capacity or rating to take care of unusual conditions. This, of course, calls for equipment of increased nominal rating or capacity if satisfactory service is to be expected.

A common mistake of the prospective user is to neglect to take into account the fact that he has unusual conditions which require the use of a service factor. This is particularly true in connection with the mechanical apparatus used in power transmission. It is not uncommon to find chains, clutches, couplings, speed reducers, variable speed drives and other devices of standard rating attached to a heavy-duty or overrated motor. The user then condemns the mechanical element if it does not stand up under the heavy service conditions.

Service ratings are as necessary as the primary ratings of equipment. Any manufacturer of either electrical or mechanical equipment welcomes the opportunity to advise a user from his experience on the allowances which should be made in the selection of equipment for any particular service.

Do Not Leave the Care and Operation of New Equipment to Chance

EVERY operating man is familiar with the inertia incidental to the acceptance and adoption of new ideas, methods or equipment. Many have also found that after a new piece of equipment is adopted for use, perhaps after a good deal of argument, it frequently happens that those who have it in charge do not understand or appreciate its value enough to take the proper care of it.

An interesting example of this was found recently in one plant. The plant engineering department had installed roller-bearing lineshaft hangers in a new addition. The oiling of these was left to the supervision of the production department foreman. During all of his years of experience, lineshafts had always been oiled every day. He could not comprehend that the new bearings required attention only at long periods and so compromised by instructing his oiler to oil them once a week. As the oiling was done while the shaft was in operation an excess of oil was poured in, only to run out again when the shaft stopped. This necessitated adding 2-qt. containers to catch the overflow.

Many plants are getting over these difficulties with new equipment which is not thoroughly understood, by having the engineering or operating departments take over its care until it is well broken in and the best methods of oiling, inspection, and control have been demonstrated by practical operation to the satisfaction of everyone concerned. Then there is little excuse or opportunity for trouble.

Standardize the External Dimensions of Mill-Type Motors

MANY attempts at standardizing industrial motors have been made, all of which have failed for various reasons. From the standpoint of the user, standardization cannot come too quickly. But from the viewpoint of the manufacturer, changing so as to meet certain standards which would not improve the performance of the motor, existing designs that have been evolved at great expense, would impose a hardship that manufacturers are undoubtedly justified in opposing.

At the present time, however, conditions have changed regarding one type of industrial motor. It is now generally understood that manufacturers are about to redesign their lines of mill-type motors, which are used extensively in steel mills. The time is, therefore, ripe for undertaking a standardization program for this type of motor.

A movement sponsored by the Association of Iron & Steel Electrical Engineers is now under way for standardizing such external dimensions of mill-type motors as will give interchangeability of motors of a given rated capacity. This Association is asking manufacturers to standardize on the following items: (1) horsepower ratings and speeds; (2) armature bearing dimensions, particularly if ball or roller bearings are used; (3) maximum external dimensions; (4) mounting bolt-hole dimensions; (5) shaft diameters; and (6) shaft tapers, keys, and keyways. With all of the manufacturers standardizing on these features it is expected that each manufacturer's mill-type motor will be interchangeable as a unit with any other manufacturer's mill-type motor of the same capacity.

This is a program that deserves the whole-hearted support of not only steel mill engineers and operators but also the operating engineers of all industries. Standardization, on the features mentioned in the foregoing, will reduce inventories of motors, bearings, armature shafts and pinions. It will enable all manufacturers to compete on equal terms on all jobs. It will make the operator's problem of spares a much simpler one and will increase the turnover of electrical stores and spare equipment. Efficiency and economy mark the operation of the plan throughout.

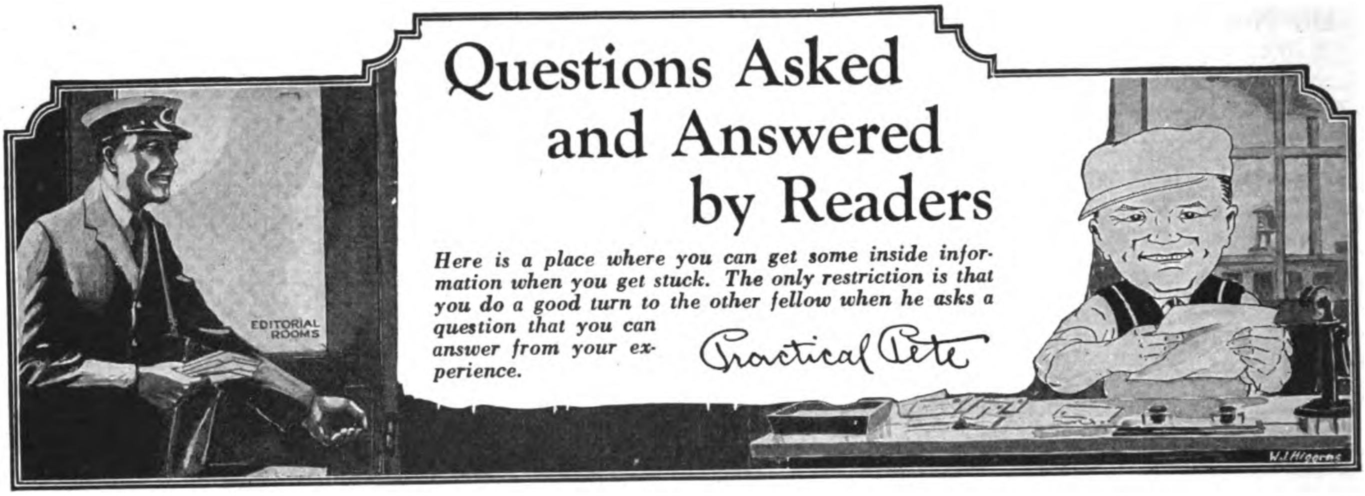
Moreover, this is the first decisive step towards the standardization of all types of industrial motors, a result that will be accomplished sooner or later, if there is an insistent demand on the part of industrial users. The Editors of INDUSTRIAL ENGINEER will be glad to have readers express their opinions on this subject.

Overvoltage on Lamps May Cost More Than You Realize

NO ARGUMENT is needed to prove that burning lamps at overvoltage shortens their life. That is a matter of common knowledge. It is also easy to see how the necessity for frequent replacement of lamps increases the cost of operating the lighting systems. There is, however, another item of expense which is likely to be overlooked: namely, the cost of replacing burned-out lamps. On this point Andrew Vogel, Plant Engineer, General Electric Co., made the following comments at a recent meeting of the Illuminating Engineering Society:

> It frequently costs more to place a lamp in a socket than the lamp is worth. When you are lamping fixtures at a height of 30 to 35 ft., or in some cases at a height of 50 to 60 ft., it is a rather expensive operation. Naturally, you want to keep your voltage just as constant as possible in order to obtain the maximum life from the lamp.
>
> In our design of wiring systems we design the copper to enable us to get a maximum of three watts per square foot at any point, or over any reasonable area. We have also designed our wiring installations so that the difference in voltage with one lamp on, or with all of the lamps in the section on, shall not be more than three volts. In other words, we do not adopt any arbitrary percentage of voltage drop. If the incoming line gives us the proper voltage we are going to get all of the usable life out of the lamp; we are going to get everything out of that lamp, from the standpoint of life and maximum efficiency, in every way possible.

Checking the voltage of the lighting circuits with a graphic voltmeter over a sufficiently long period to enable the variations to be determined, and study of your lamp replacement records, may point the way to a worth-while saving in the operating and maintenance costs of your lighting system.



Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Practical Pete

Who Can Answer These?

Method of Marking Rubber Gloves.—I would appreciate receiving any information concerning satisfactory methods of marking linemen's rubber gloves which are periodically subjected to electrical tests, as I wish to mark on the gloves the date of the last test. These gloves are used constantly for both inside and outside construction work. Any help that readers can give me will be greatly appreciated.

Lowell, Mass. J. H. J.

* * * *

What Are the Comparative Advantages of Two-Point and Four-Point Adjustable Hangers?—I am planning on installing an additional section of lineshaft and would like to get the opinions of other readers about whether to use two-point or four-point adjustable hangers. What are the advantages of each from the installation, operation, and maintenance standpoints? Would these advantages be worth the difference in cost? This will be a 1 15/16-in. shaft, 50 ft. long. The present installations are all two-point adjustable hangers. Will other readers tell me what they would use and why?

Indianapolis, Ind. B. K. W.

* * * *

Heating of Commutator on Rewound Repulsion-Induction Motor—I recently rewound a G. E. single-phase ½-h.p. four-pole type RI 110-volt repulsion-induction motor and am having trouble with it on account of heating. The commutator seems to heat first and in about two hours the motor gets so hot that you cannot put your hand on it, and it keeps on getting hotter. It does this when running idle. I have tested the commutator, armature, fields, and bearings and they seem to be O. K. The armature is well balanced. I used No. 16 d.c.c. wire in the rotor and main field and No. 18 in the compensating field. I shall appreciate any information regarding the cause and remedy of this condition.

Hubbard, Ore. R. S.

* * * *

Changing 25-Cycle Brake Coil to 60-Cycle Service.—I am having a little trouble in changing over a brake coil from 25-cycle to 60-cycle service. This coil is used on the brake on the hoist motion of a 10-ton traveling crane. The coil was originally wound with about 1,400 turns of No. 21 magnet wire for 25-cycle service. I have rewound the coil using 800 turns of No. 15 wire, but the coil only lasted a few days before burning out, and it does not seem to have the lifting power of the old coil when used on the 25-cycle service. This coil was formerly connected across a 440-volt, 25-cycle power supply and will be used on the same voltage for the 60-cycle service. The diameter of the smallest turn is about 2 in. and the largest turn about 4 in. The coil is in reality a solenoid with a plunger working through the center of it. Can some reader tell me how many turns to use on this coil and what size of wire should be used in order that I may use it on the 60-cycle power supply?

Green Bay, Wis. H. B.

* * * *

Drying Out Direct-Current Motors.—One of our largest steel works was recently flooded, due to the breaking of a dam. About 500 direct-current, shunt-wound, 250-volt motors, ranging in size from 10 to 250 hp. have been under water for 10 days. Our problem is to dry out these motors in the shortest time. The greatest difficulty encountered is in drying out the shunt-field coils. Drying out in an oven is rather slow, due to the large number of motors that must be taken care of. I would greatly appreciate learning from readers what methods they would suggest for drying out these motors, particularly the field coils.

Bressoux, Liege, Belgium. P. V. H.

* * * *

Are Transformer Laminations Injured by burning off Oil and Insulating Compounds?—I will appreciate it if some readers can give me the following information: Does heating transformer laminations to remove the insulating compound and oil injure them? Is it standard shop practice to do this? How much will the iron loss be increased, if any, by this procedure? If the laminations are japanned after burning off the oil and compounds, will this cut down the core loss? Will an oxide form on the iron, during the heating, which will cut down the core loss? How hot may the iron be heated without injuring it?

Santa Ana, Cal. C. C. B.

* * * *

Trouble with Solder.—We are having considerable trouble in making soldered joints hold on rectangular wire in coils that are subjected to rather high temperature, such as might be the case in series field coils and brake series coils. We have tried an 80 lead—20 tin solder, but it melts due to the excessive heat. Can our readers suggest any methods that will enable us to join these wires together in a manner that will stand rather high temperature? I shall be very much indebted to any reader who can give me some help in this matter.

Norton, Va. W. H.

* * * *

Overload Protection for Generators.—(1) We have installed in our power plant, two 2,000-kva. generators and two 4,000-kva. generators all of which are rated at 2,300 volts, three phase, 60 cycles, 3,600 r.p.m., and are driven by steam turbines. What protection should we have on these generators? Should reverse power relays, or overload relays, or both be used? Are these relays necessary and also what other protection is required on these machines? The four machines are arranged to be paralleled together and quite often all of them are running simultaneously. (2) We have installed one 50-kw., 125-volt, motor-driven generator which operates in parallel with two 100-kw. steam-driven exciters for supplying field excitation for synchronous motors. Should we have circuit-breaker protection on these machines and if so, should a three-pole circuit breaker be used? I shall appreciate any information that readers can give me regarding these questions.

Detroit, Mich. R. J. B.

* * * *

Winding Rectangular Wire on Edge.—I would like some suggestions from readers on how to wind coils, using rectangular wire or ribbon. These coils have to be wound with the copper on edge. My particular problem is the mechanical operation of winding the thin copper strips on edge without using too elaborate a machine. To be specific, I desire to wind both a round and an approximately square coil, using 1/16-in. by ¾-in. copper ribbon. The diameter of the core of this coil should be 1 in. and in the case of the square coil, the side should be 1 in. I also desire to make up a coil around a 1-in. core using strip copper 0.01 in. by 1 in.

Bloomington, Ill. A. S.

* * * *

Answers Received To Questions Asked

How to Support a Mule Stand.—We are planning on a lineshaft installation in which it will be necessary for the shaft to extend across the room, with an additional section to be installed at right angles along the side wall. We have been considering using a mule stand but some of our men who have had experience with this device in other shops advise going to the expense of separating the shafts and using two motors.

I should like to know the methods other readers have used in supporting such stands and lubricating the pulleys and the results they obtained. This is a mill-construction building with a 2 15/16-in. main shaft and a 1 15/16-in. shaft on the extension.

Milwaukee, Wis. R. C. A.

I believe that R. C. A. has the choice of two methods of supporting his mule stand. The first is to extend the shaft up to a support such as a roof girder, ceiling beam, or the like. A bearing may be mounted at the top and bottom and clamped tightly to the shaft to keep it from rotating. Provision should be made so that the shaft can be moved slightly in any direction for alignment. The second method, which is necessary where an overhead support is lacking, is to brace the upper end of the shaft by means of four truss rods of heavy

construction. These should extend to the walls or floor.

However, I believe that a mule is undesirable as there are usually lubrication and belt troubles due to the fact that the space is cramped, which necessitates a short, tight belt. An idler still further complicates matters. Much the better method is to install a bevel gear drive. This has the advantage of requiring very little space, no overhead construction and slight attendance. A gear drive of the size given by R. C. A. would have one iron gear and one inserted, wooden-tooth gear.

A most important point is that if a ratio of, say, one to one is selected, and it need not be absolute, one gear may have say 100 teeth, while the other would have 99 or 101. This results in the teeth wearing more evenly and so giving more silent operation. It is possible to use any desired ratio but it is well to see that the number of teeth in one gear is not a multiple of the number of teeth in the other.

Chief Engineer, PHILIP N. EMIGH.
The Mountain Water Supply Co.,
Indian Creek, Pa.

* * * *

In answer to R. C. A.'s question about the practicability of using a mule stand for cross-shaft driving, I would say that he seems to have touched on the two most important points when he mentions the support and the lubrication. When properly installed and maintained there is no reason why that type of drive should not be satisfactory in every way; if, however, certain points are neglected the mule drive can be just as cantankerous and stubborn as its more famous namesake is credited with being.

The accompanying sketch shows one of many such drives which I know from experience are giving no trouble whatever and are almost noiseless in operation. The only attention required is to screw down the grease cups daily.

The main points considered in the layout and installation of this drive are its supports and lubrication. Figs. I and IV show how the mule stand is supported and braced. The arbor *a* is threaded into a 10-in. flange, *b*, which is bolted onto the bottom side of a 10-in. by 12-in. timber. Two guy rods, *c* and *d*, with turnbuckle adjustments are attached to the bottom of arbor *a* to counteract the belt pull. This might appear to be an unnecessarily heavy and rigid support for a light drive, but the worst enemy of the mule drive is vibration and the more vibration can be eliminated, the better the drive will operate.

The other important factor, lubrication, is taken care of in this particular drive by grease cups which force common grease into the end of a hollow shaft and out through small grease holes, as shown at *i*, Fig. II. The bottom of the pulleys, Fig. III, is finished as shown at *k* and is supported by the bottom *l* of the cup *m*; this cup also helps to retain the grease which is forced down through the hollow shaft and under the pulley by the grease cup above.

This method of lubrication is quite satisfactory for light drives. These sketches show a drive with a 2 15/16-in. main shaft and a 2 7/16-in. cross-shaft with a 4-in. belt. The mule pulleys operate at 600 r.p.m. For a heavy drive, however, where it is necessary to use a 10-in. or a 12-in. belt, roller bearings should be used on the shafts and ball-thrust bearings under the pulleys.

There are a few other points which will also make for satisfactory operation: one of these is to fasten a support, *h*, Fig. I, to the end of the arm *e* which carries the pulley on which the slack side of the belt runs when the load is applied. When this is not done a sudden load will often cause the belt to drop off, although it takes very little to support it.

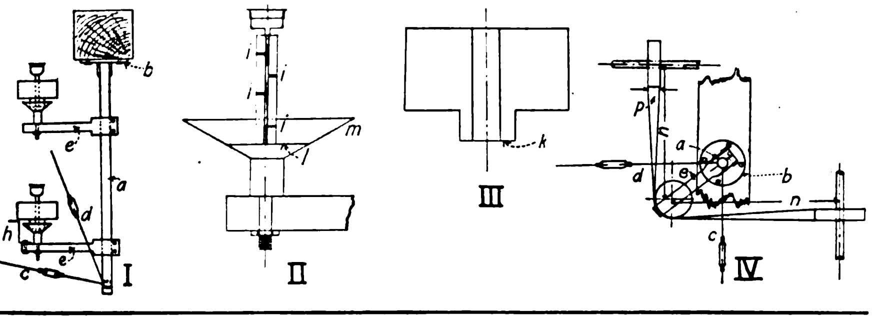
It is also good practice, wherever room permits, to make the distances *n*, Fig. IV, between the centers of the pulleys and the centers of the driving and of the driven shafts, a number of feet which will be at least twice the width of the belt in inches; thus, for a 6-in. belt the distance between shaft centers should be 12 ft. The reason for this is that the belt is twisted one-quarter turn and if that quarter twist is taken in too short a distance the life of the belt will be considerably shortened and the drive will tend to give more trouble through vibration.

Belleville, Ont., Can. J. H. GALLANT.

* * * *

From my experience with a mule stand, I would strongly advise R. C. A. to drop the idea altogether especially for a permanent installation. If it is necessary to run one shaft at right angles to the main shaft by all means use another motor and drive this shaft independently. The saving in power alone will soon pay for the motor, to say nothing of the installation and maintenance costs of a mule stand.

Construction, bracing and method of lubricating a mule stand drive for a 4-in. belt with the mule pulleys operating at 600 r.p.m.



It is very difficult to line up a mule stand so that the belt will run right on all four pulleys. There is no rule that can be applied; it is simply a matter of cut and try. Moreover, to lubricate the pulleys on the mule, it is necessary to shut down to fill or screw down the grease cups. The power waste is enormous and the best belt will not survive long when used over a mule stand.

For very light power transmission, involving not more than 2 or 3 hp., a mule might be more practicable, but from the size of shafts named in the inquiry, I surmise that R. C. A. expects to transmit a considerable amount of power. GUY H. WINTERSTEEN.
Cleveland, Ohio.

* * * *

If R. C. A. remembers that the same rule applies to mule stands as to all other pulley practice, that is, that the belt must run in such a way that it will feed onto the pulleys in a straight line, he will have less trouble. Mule stand pulleys operate most readily if the same size pulleys are used on the driving lineshaft and on the driven lineshaft. It is, of course, essential not to use a pulley of a diameter too small for the weight of belt. The diameter of pulleys to be used on the lineshaft is immaterial.

Some industrial plant men prefer to use flanged pulleys on the mule stand, but this is not essential, and unless the pulleys are aligned absolutely the belt will wear on one or the other of the flanges.

One of the best methods of securing the mule stand, wherever possible, is to use two shafthangers placed horizontially on a heavy post. Where a post or a wall is not convenient, the shaft of the mule stand may be attached to the ceiling or floor by mounting one end in a cast iron socket or floor plate screwed to the ceiling or floor. The other end is braced by guy wires or cables preferably with a turn-buckle in them for taking up any slack and giving sufficient tension, so that the mule stand will maintain vertical alignment, even when the drive is operating under full belt tension. A mule stand must be erected very substantially or it may be pulled down in case the belt breaks, as was once experienced by the writer.

Elgin, Ill. SVEND E. SALOMONSEN.

* * * *

What Shop Equipment Will Be Required Here?—I would like to have some of our readers tell me what equipment they think will be necessary for a shop to handle a general motor repair business in a city having a population of 50,000. I wish to have as completely equipped a shop as is consistent with the amount of repair work that I may expect to do in a city of this size. Any recommendations as to kinds and makes of equipment necessary, will be very much appreciated. Also, I should like to know what kinds and amounts of supplies, such as insulated wire, insulation, varnishes, tapes, etc., should be carried in stock.

Pedro Miguel, Canal Zone. P. F. W.

Answering P. F. W.'s question, a great deal would depend upon the size and type of machinery used in this town, and whether the power supply is mostly alternating or direct current. I

presume that it is alternating current. The average contracting shop for repairing motors, transformers, and control equipment is established in a building approximately 60 ft. by 80 ft.

Regarding the selection of equipment, the following suggestions are offered: He will need a lathe with at least a 9-in. swing, which will permit rotors or armatures of about 18 in. diameter to be handled. A grinder with fine and coarse wheels about 8 in. in diameter and a small power drill for taper-shank bits, with an adjustable, round shank for small drills, will be needed. Coil winding equipment which may be obtained with the motor attached is the most suitable because there are no lineshafts or belts to install. At least one taping machine will be necessary. I would recommend the coil winding machine and attachments invented by S. H. Browning and manufactured by the Mutual Foundry Co., Atlanta, Ga. This company also makes a coil spreader. These machines are used by many electrical repair shops and are advertised in INDUSTRIAL ENGINEER.

For dipping and baking, a sheet-iron tank about 2 ft. deep, by 4 ft. wide and 6 ft. long, will be found suitable for this purpose, although the dimensions may be altered as necessary. I would recommend a ventilated oven about 6 ft. long, 5 ft. wide and 5 ft. high, built of brick or some other insulating material. This oven may be electrically heated, if gas is not available, or it may be either oil fired or steam heated, if desired.

Equipment for heating ovens with oil may be obtained from Hauck & Co., Brooklyn, N. Y. A monorail system with a 1-ton, chain hoist is almost a necessity. This monorail should extend the full length of the shop and be arranged so that it passes directly over the lathe, the dipping vats, right into the oven. A switch should be arranged so that motors can be handled from trucks at the doorway, or so that trucks can back under the monorail.

One or two armature racks should be built of 4-in. by 4-in., or 4-in. by 6-in. timbers, bolted together and well braced. A table of heavy material should also be built for supporting stators, while being wound. Both table and armature racks should have casters about 3 or 4 in. in diameter; smaller casters are a source of annoyance. The workbench should be provided with drawers for hand tools and should be well lighted both for night and day work, since there will be many overtime jobs on elevators and other important equipment.

The supplies needed will vary somewhat, depending on whether the equipment to be repaired is large or medium-sized, and also on whether the larger portion is a.c. or d.c. If the town of Don Miguel does not have an electrical supply house, the stock would probably have to be larger than ordinary. The following stock of tape will be required: 1-lb. rolls of ¾-in., friction tape; ¾-in., cotton tape in rolls about 3½ in. in diameter, for use on the taping machine and ¾-in., varnished-cambric tape in 3½-in. diameter rolls so that it may be used on the taping machine for high-voltage equipment. The thickness of the tape should be from 0.010 in. to 0.015 in.

Fishpaper is the most commonly used insulating paper and the untreated variety is the most flexible. The moisture content is only about 7 per cent, which can be reduced by heating the machine before dipping. The thicknesses generally used are 0.010 in., 0.015 in. and 0.020 in., which may be combined to obtain almost any thickness desired. A supply of fibre sheets 18 in. by 30 in. and of 1/8 in., 1/16 in. and 1/32 in. thickness will be needed for wedges and strips. Flexible mica, used for insulating transformers, molding mica, used for commutator cones and slip ring insulation, and commutator segment mica come in sheets approximately 18 in. by 30 in. and should be obtained in thicknesses of 0.020 in., 0.025 in., 0.030 in. and 0.035 in. Molding mica sheets 0.045 in. and 0.050 in. thick should also be obtained. An insulation cutter should be bought, as it will be found useful in cutting tin clips for bands and fastening coils before taping. It will also be found necessary in preparing insulation for closed slot stators and other equipment. Several sizes of cotton sleeving should be stocked and if d.c. or wound-rotor a.c. motors are to be repaired, various thicknesses of carbon and one or two sizes of pigtail wire will be needed for brushes.

Magnet wire will be an important item in your stock. It is made round, square and rectangular, which would make it impossible to stock every size and shape required; so the best thing to do is canvass the possible customers and ask permission to check up on their equipment. Obtain the horsepower and note whether d.c. or a.c., single- or poly-phase. Also note the temperature rating. Procure a wire gage and find the size of wire, from a stub, if the motor is of unusual design or size. The average a.c. or d.c. armature will have wire ranging from No. 9 round to No. 17 round. In small motors the wire will range from No. 20 to No. 33. Large stators and wound rotors sometimes have square, and in other cases rectangular, wires. In an emergency substitute round wire for this odd-shaped wire, but try to keep the circ. mil area the same, using the wires in parallel. Sometimes on a.c. windings the slot span can be changed to make up for the loss of copper. Copper bars can be reinsulated.

Paint is to the armature winder what putty is to the carpenter, "a friend in need." I prefer yellow or amber baking varnish for oilproofing; when the finished machine is removed from the oven, and is still hot, I spray or brush it with black air-drying varnish. Black varnish gives a neat appearance and also makes the machine practically waterproof.

Tinned steel wire, sizes No. 16 to 21, will be required for bands on single-phase and wound rotors and d.c. armatures. Burnley's soldering paste and soldering acid will be needed, as well as half-and-half solder wire, which is sold by the pound on reels weighing from 10 lb. to 50 lb. A solution of denatured alcohol and rosin can be used as a flux for soldering armature bands. Shellac gum is bought by the pound, or it may be purchased already prepared in one quart or larger containers. Amber shellac is best for all-around use. Glue should be bought in half-pint or pint cans, Le Page's glue is considered good.

P. F. W. will have to use his own judgment in selecting material, as he is familiar with the district in which he is located and knows whether he has any competitors, and their strength. He can also determine the amount of equipment installed in the town or district and from this determine what materials he should have on hand.

Birmingham, Ala. GRADY H. EMERSON.

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Misleading Results Sometimes Obtained from Magneto Test.—Sometimes I get rather misleading results through the use of a magneto to determine whether there are defects in some of our electrical apparatus. Under certain conditions I have found that the magneto will indicate a dead ground, whereas further investigation shows that the equipment is in very good operating condition. Also, I have found that a magneto will sometimes indicate an open in a shunt-field coil, when further investigation shows that the field coil is O. K. I should like to know if any readers have had similar experiences and can explain the reasons for this peculiar action of the magneto. Also, can you suggest other test methods that might be used under the conditions mentioned?

Omaha, Neb. M. P.

Answering M. P., the misleading indications to which he refers are the result of the alternating current produced by the magneto. If the equipment being tested has an appreciable electrostatic capacity, it acts as a condenser and permits the alternating current of the magneto to flow and thereby a ground is indicated even when the insulation resistance is high.

The false results indicated while testing shunt field coils are due to the inductance of such coils, which may be so high as to prevent the alternating current of the magneto from flowing, thus indicating an open circuit.

It is much better to use a direct-current source of supply for such tests. There is an instrument available known as the Junior Megohmer (made by Herman H. Sticht & Co., New York, N. Y.), which furnishes 110 volts direct current and is well suited for tests such as mentioned by M. P. The cost of the instrument is very little more than that of a good magneto. It has a range of 20 megohms and is, therefore, suited for many other tests which cannot be made with a magneto.

New York, N. Y. GEORGE O. POWERS.

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Answering the question asked by M. P. regarding the use of our old standby, the magneto, I would say that many place too much confidence in magneto tests and consequently are often misled, causing much trouble and useless expense. Magnetos are all right to use on lighting circuits or motor circuits in conduit or otherwise, but they are useless in testing a circuit or a number of circuits of high capacity. I have tested circuits with a magneto and found them apparently grounded, but in testing the same circuit with the proper apparatus the insulation was found to be excellent.

The best instrument any electrical repair gang can have around the shop is a megger. This does not necessarily have to be a large expensive outfit. The small megger in the aluminum case, put on the market by James Biddle, is very handy for all-around testing and will not give misleading results if properly used. Any good instrument of this type will be found to be worth many times its cost in an industrial plant of any size, especially one large enough to have electricians.

The megger can be used for making periodic tests on motors, starters and many other pieces of electrical equipment. If records are kept of these periodic tests on cards or charts where they can be referred to from time to time, many costly shut-downs may be averted because the condition of the equipment will be known in advance and may be repaired before it finally gives out, causing serious damage. If it cannot be repaired at the time, spare equipment can be made ready to take its place on short notice. An hour saved in many large industrial plants is well worth the price of any such insulation testing instruments.

Chief Electrician, LEE F. DANN.
Donnacona Paper Co.,
Donnacona, Que., Can.

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Replying to M. P.'s question in a recent issue; nearly all magneto test sets generate alternating current. Since this is the case, the flow of current will not be limited by the ohmic resistance alone, but will be limited by the impedance of the circuit. The impedance of the circuit in ohms is equal to the square root of [the resistance squared plus (the difference of the inductive reactance and the capacitive reactance squared)]. The use of an alternating-current test set on a circuit containing capacitive reactance or inductive reactance would require some information concerning the relative magnitude of the quantities involved. This information is usually not available and for this reason the use of the magneto test set is rather limited in its application.

Practically all electrical machinery has a considerable amount of inductance or inductive reactance. The inductance of a circuit is directly proportional to the magnetic flux, the number of turns, and inversely proportional to the current. From the above it is seen that a large number of turns or an iron core will greatly increase the inductance of the circuit.

A shunt field coil has a very large number of turns and also has an iron core, and consequently has a large amount of inductance. The inductive reactance is directly proportional to the inductance. If the capacitive reactance is zero and the ohmic resistance is small in comparison to the inductive reactance, the impedance will be largely determined by the inductive reactance. All magneto test sets are rated to ring through resistance and not through impedance. In the above case the impedance is very large and the resistance is small; hence the magneto will indicate an open circuit because of its inability to ring through the high impedance of the field coil.

To test shunt field coils, when the magneto indicates an open circuit, direct current must be used. Several dry cells connected in series will in most cases give good results.

When the magneto indicates a ground or a short-circuit when none exists, it is caused by the capacitive reactance of the apparatus. The capacitive reactance is inversely proportional to the frequency and to the capacitance. The capacitance of a condenser is the measure of this condenser to hold a charge. Two conductors separated by a dielectric form a condenser. From this it is seen that all electrical apparatus must be composed of a large number of condensers.

Alternating current will flow through a condenser and as the magneto generates an alternating current and if the apparatus has sufficient capacitance, the magneto will indicate a ground or a short-circuit where none exists. Therefore, it will be necessary to apply some other test. As a rule electrical machinery does not have sufficient capacitance to cause the magneto to indicate a ground, this being more noticeable on transmission lines.

For insulation testing the Megger manufactured by the James G. Biddle Company, Philadelphia, gives excellent results. For information concerning its operation and construction, refer to literature of that company. It may be of interest to note that the Megger has a direct-current generator and for that reason it may be used where magneto test sets would give misleading results.

CHAS. F. CAMERON.
Rock Springs, Wyo.

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In reply to M. P.'s question, I would say that I have used the ordinary magneto testing set successfully for several years on general troubleshooting. It is a fact, however, that the high-resistance magneto will ring apparent grounds when they do not exist. But if one is careful in testing and turns the magneto handle himself he will find that the handle turns easily when the ground is "false." When the ground is "dead" or positive, the handle of the magneto will be found to turn hard; that is, it will be harder to turn than in the case of a "false" ground. The "false" ground also rings the bell with a fainter tone. If the magneto has about a 16,000-ohm rating it will be found to give better results for general testing of circuits and equipment. A 35,000-ohm magneto is not very well suited for ordinary work, but can be used to better advantage on high-voltage equipment, such as 6,000 volts and higher.

A very good ground testing outfit can be made by using an ordinary potential transformer such as used for voltmeters and other switchboard instruments. The usual tests are for 2,200 volts and below; so a transformer of 2,200/110 volts rating can be used. The low-tension side of the transformer may be connected to any 110-volt circuit through a fuse, while one side of the high-tension winding is connected to the machine or circuit to be tested, the other wire being connected to ground. If the machine or circuit is defective the primary fuse will blow. This is a fairly reliable test even on 2,200-volt equipment of small capacity. For finding grounds on stators and like equipment (provided no other method is handy) the normal voltage of the machine can be applied to one wire through a fuse and the oil switch thrown in; an arc is usually visible at the grounded coil.

On 500-volt shunt fields and some designs of 250-volt fields, the magneto gives a faulty indication; that is the bell does not ring, thereby indicating an open-circuit. Try breaking the magneto circuit while ringing; a small spark is usually visible if the circuit is not open. A magneto of 50,000 ohms will usually ring on these fields. If the voltage on which the fields operate is available they can be momentarily connected directly across the line. If the field has a magnetic pull or gives an arc upon breaking the circuit, the field is not open.

A magneto test is not infallible, however, as I well remember after intermittently testing a shunt field on a small motor for three or four hours. A circuit was indicated each time, but the motor operated as if it had an open field. Finally I pulled the lead wires to each field and found one of them to be loose. GRADY H. EMERSON.
Birmingham, Ala.

* * * *

The reason that M. P.'s magneto indicated that a good machine was grounded, is because the machine had a small amount of electrostatic capacity between the conductors and ground. The magneto generates alternating current which, when impressed on even a small amount of electrostatic capacity, delivers a sufficient amount of current in charging the "condenser" to ring the magneto bell. Almost any motor, generator, rotary converter or power cable has some electrostatic capacity and, therefore, the magneto is of relatively little value for making tests on them.

As to why the magneto did not ring through the field coil—this is a case of inductance, which may be considered as the opposite of electrostatic capacity. The inductance acts as a "choke" to the alternating current from the magneto, to such an extent that the current which does pass through the coil is too small in amount to ring the bell.

This inductance phenomenon also makes it very difficult to use a magneto with any degree of reliability for testing insulation of field coils. For example, if the coil is grounded near one end of its winding, and the magneto is connected to the other end, the inductance through which the magneto current will have to pass before completing its circuit, may be so great as to prevent the bell from ringing. Or, if the ground is at the center of the winding, a test either way may still show clear on account of the inductance of the coil.

It is the writer's experience that the so-called magneto is of little or no value either for testing grounds or for test-

ing field coils. It rings through electrostatic capacity and does not ring through inductance. Also, a magneto gives no accurate idea as to the insulation resistance value in ohms, of the apparatus tested. On this point, when a test of insulation is made and the bell does not ring, one knows only that the insulation resistance is greater than a certain amount, this being the resistance rating of the magneto. Practically the only good use for a magneto is in testing the continuity of wiring.

The best way to test field coils is to connect them in series with 110 or 220 volts d.c. through a suitable lamp bank if necessary. Then, with a voltmeter, measure the drop across each coil. This test shows whether the windings are continuous, and also tells by comparison whether the coils have approximately the same number of turns. If the coils are known definitely to have the same number of turns of the same kind of wire, a variation in the voltmeter readings indicates short-circuited turns in the low-reading coils.

For testing insulation resistance an insulation resistance measuring instrument, such as a Megger testing set will be found useful. The Megger is a direct-current generator outfit, and has a direct-reading ohmmeter scale on which may be read the actual value of the insulation resistance. A recent modification of the Megger, known as the Meg Insulation Tester, generates 500 volts direct current and the scale reads up to 100 megohms (100,000,000 ohms), the first mark above zero on the scale being 10,000 ohms. Small amounts of electrostatic capacity do not affect the reading of this instrument. Neither is it affected by the speed at which the crank is being turned by the operator.

For large machines with a considerable amount of electrostatic capacity, use may be made of the Super-Meg, which generates a constant voltage by means of a slip-clutch arrangement when the crank is turned above its rated speed. Instructions for using these instruments are contained in our pocket manual 1060E. I shall be glad to send a copy of this manual to M. P. or to any reader who is interested in insulation resistance measurements.

James G. Biddle, Philadelphia, Pa. T. B. WHITSON.

* * * *

Replying to the question by M. P., the use of a magneto in testing is very likely to give misleading results, except in such work as is within the range of the instrument. A magneto is, in general, designed to ring through 20,000 to 40,000 ohms resistance. Electrostatic capacity must be considered when using the magneto in testing long circuits or cable circuits as it is this capacity that will cause the bell to ring and indicate a short-circuit, whereas no short-circuit may exist in this case.

Iron in a circuit has quite the opposite effect, but this is due to the inductance of the circuit which tends to prevent current from flowing, indicating an open circuit, and must be considered when ringing out the field coils of generators, motors and the like. Test bells and test lights are useful in many instances and also there are different devices on the market which are used as fuse testers to simplify testing work on electrical circuits. A telephone receiver may be wired as a circuit tester and is often used in this respect. The A. V. O. tester has a number of qualities to recommend it to the average electrician who does not have the money to spend for various instruments, as it is a combination voltmeter, ammeter and ohmmeter.

West Allis, Wis. EDWARD JAMES.

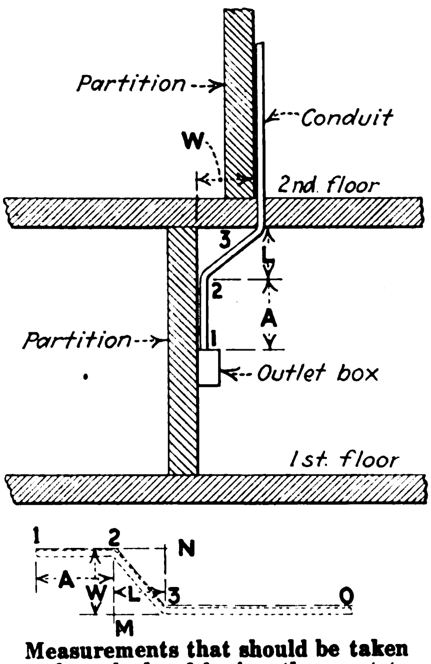
* * * *

Measurements Required for Bending Conduit.—When bending conduit by use of a hickey, what measurements should be taken for making an offset, so that I can bend several conduits and have them match when placed side by side? I find it hard to get both sides the same on a double offset. Can some reader tell me how I can make a good-looking job by the use of a hickey on this kind of bending? If any readers have other devices or methods for making double bends and offsets I should like very much to know about them.

Worcester, Mass. R. S. T.

In answer to the question asked by R. S. T. regarding a method for accurately measuring an offset that is to be made in a conduit, I have used the following method with very satisfactory results.

For example, assume that a conduit is to be installed as shown in the accompanying illustration. It is to be run from an outlet box on the wall of the first floor, as at point *1*, up to the wall to the offset and then run up through the second floor and extend upward along the partition on this floor, as is shown in the diagram. To make an offset in a conduit so as to fit this location accurately, the procedure is as follows: First, measure the distances *A* and *L* between the points *1* and *2*, and *2* and *3*, respectively. Make the distance *L* as short as possible. Then measure the distance *W* between the wall on the first floor and the wall on the second floor; this is, in reality, the distance offset by the two walls.



Measurements that should be taken and methods of laying them out to insure making accurate offsets in conduits.

Then upon the floor or any flat surface that is convenient, lay off these distances as measured. In the bottom diagram these distances are laid off, the distance *A* being laid off as a straight line between points *1* and *2*, the distance *W* being laid off at right-angles to *A* between the points *2* and *M*; the distance *L* is laid off on an extension of the lines *1-2* between the points *2* and *N*. The line *N-3* is drawn in perpendicular to the line *1-2-N*; likewise line *M-3* is drawn in perpendicular to the line *2-M* to form the rectangle, *2-N-3-M*, as is shown in the diagram. The line *M-3* is then extended to the right, as is also shown in the diagram.

The diagonal to this rectangle is now drawn as shown at *2-3*. Conduit must then start at point *1* and follow along the line *1-2* until it reaches point *2*; it is then bent down to follow along the line *2-3* until it reaches point *3*, where it is then bent up or offset to follow an extension of the line *M-3* which is parallel to the line *1-2*. In other words, the line *1-2* represents the partition on the first floor and the line *3-O* represents the partition on the second floor. The line *N-3* represents the ceiling of the first floor, while point *2* is the point at which the offset or first bend is started. From this diagram the total length of conduit required can be measured directly according to the dimensions obtained.

In making the offset in the conduit, first place one end of the conduit at point *1* and at point *2* mark the conduit for making a bend. After making a bend by means of a hickey at point *2* until the conduit has been bent so as to coincide with the line *2-3*, point *3* can be marked on the conduit for the second bend. Then with the hickey at point *3*, bend the conduit upward until it coincides with the line *3-O* as shown in the diagram.

This is an exceedingly simple method of measuring and making an offset so that it will fit on the first trial and thereby eliminate unnecessary climbing of ladders and waste of time in trying and fitting, as prevails under the bend-and-try method and which also makes it difficult to do a good job.

By measuring the distance *A* one can avoid the necessity of cutting a short piece of conduit to piece out to the required distance. Special pains should be taken in measuring the distance *W* to insure that the exact distance is obtained between the two walls against which the conduit is to lay. The accuracy of this measurement makes all of the difference between a neat-appearing and a poor installation.

Plant Electrician, Freiberg Mahogany Co., New Orleans, La. OVIDE C. HARRIS.

* * * *

Replying to the question asked by R. S. T., I wish to submit the following data which I clipped from *Popular Mechanics* some time ago. I have used these data and find that with a little practice one can make right-angle bends in ½- and ¾-in. conduit quite accurately. With the larger sizes of conduit, it is necessary to use a bending machine. I use either a Lakin (made by Thomas & Betts Co., New

Data for Laying 90-deg. Bends in Conduit				
Size of Conduit In.	Outside Diam. of Conduit In.	Standard Radius of Bend In.	A (—) In.	C (+) In.
½	⅞	4½	5	2
¾	1 1/16	5⅜	6	2½
1	1 5/16	5¾	6½	2½
1¼	1⅝	7¼	8	3¼
1½	1⅞	8½	9½	3¾
2	2⅜	9½	10½	4¼
2½	2⅞	10½	12	4½
3	3½	13	14¾	5¾
3½	4	15	17	6½
4	4½	16	18¼	6¾

York, N. Y.) or an Austin hickey (manufactured by M. B. Austin & Co., Chicago, Ill.) Either of these devices will give very satisfactory service.

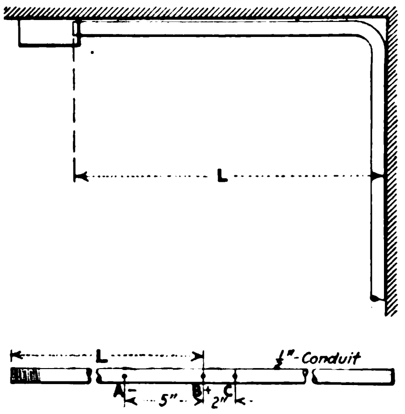
The data for measuring a conduit for the bends are given in the accompanying table. An example of the use of this table is shown in the accompanying illustration. Suppose that a ½-in. conduit is to be run from the ceiling outlet box shown in the top illustration across the ceiling and down the wall.

Take a length of ½-in. conduit and lay out the distance *L* as shown in the bottom illustration. Locate in the first column, "Size of Conduit," the size of conduit you are working on—in this case, ½-in. On this line, you will find 5, under column "A—In," and 2 under column "C+In."

Then from point *B* on the conduit in the bottom illustration lay off 5 in. to the left as shown at *A*. Also lay off 2 in. to the right, as shown at *C*. Then start the bend at *A* and finish it at *C*. If the measurement *L*, in the top illustration is made to the conduit, instead of the wall, as is shown in the illustration, the diameter of the conduit must be added to the distance used as *L* in the bottom illustration.

Method of measuring conduit for making bends.

By means of the table, the points *A* and *C* are located with reference to *B* which is placed a distance of *L* from the end of the conduit. The bend is started at *A* and finished at the point *C*.



I use a 3-ft. piece of 1-in. conduit to slip over ½-in. conduit, and a 1¼-in. pipe to slip over ¾-in. conduit.

GEORGE W. STIRTON.
San Bernardino, Calif.

* * * *

Low-Voltage Generator Will Not Excite.—It was necessary to rewind the shunt field coils of a 50-volt generator of very low capacity, which is direct-connected to a small motor having a speed of about 4,000 r.p.m. It is a two-pole machine having 2,000 turns of No. 37 wire in each shunt field coil. When the winding was completed, the machine generated 55 volts satisfactorily. It was then found necessary to reverse the generator position with regard to the motor, which of necessity reversed the direction of rotation; due to this reversal of rotation the residual magnetism of the generator was lost. When I separately excite the shunt fields from a 50-volt, direct-current bus the generator develops its proper voltage. When I reconnect the fields to the armature terminals I get a reading of only 1 volt. I wish some reader would tell me what is wrong and how I can correct this trouble.

Stamford, Conn. W. E. H.

In answer to W. E. H., it would appear that he is magnetizing the shunt fields for one polarity with the separate excitation and reconnecting the fields to the wrong armature terminals, so that the armature current bucks the residual magnetism that has been just built up.

To correct this either (1) connect the fields as formerly to the separate excitation, but reconnect them to the oposite armature terminals after separately exciting them, or (2) connect the fields to opposite terminals of the separate excitation and make the same reconnection of field leads to the armature as was formerly used.

CECIL W. ZIMMERER.
New York, N. Y.

* * * *

In answer to the question that was asked by W. E. H., I presume that his generator is a shunt-wound machine. When he changed the rotation of the generator mechanically he should have changed it electrically, and this is done by interchanging the shunt field leads at the armature. The very fact that it generated when first started and failed when he changed the direction of rotation, is sufficient evidence that there is nothing seriously wrong with the generator and his only trouble is that the reversed polarity of the armature (due to reversed rotation) tends to send current through the shunt fields in the oposite direction to that formerly obtained, with the result that the residual magnetism in the field poles is killed and the generator does not build up.

WM. P. AMANNS.
Chief Electrician,
Knoxville Iron Co.,
Knoxville, Tenn.

* * * *

Answering W. E. H., the general description of the difficulty does not make any reference to the position of the brushes or the operation of the generator as to sparking at the commutator. While the flow of current in the field of a shunt generator is the same when operated as a motor or generator provided it revolves in the same direction as before a reversal of rotation, as outlined in the question, will cause a reversal in the generated voltage; hence the flow of current in the field winding will be reversed and the electromagnetism set up in the field core will oppose the residual magnetism so that the resultant magnetism for a self-excited machine will be practically zero. Hence, no voltage will be delivered by the machine when self-excited, unless some means such as separate excitation is used to give the residual magnetism the correct polarity, or by reversing the field connections, which will also give the same effect.

It will also be necessary for satisfactory operation to shift the brushes, in the direction of rotation, to a point where satisfactory commutation is obtained; that is, the electrical neutral point shifts ahead with a change of rotation, to a point which has the same angular relation with the mechanical neutral as before.

It is assumed in the foregoing discussion that the generator is of the non-commutating pole type.

C. OTTO VON DANNENBERG.
Designing Engineer,
Sanderson & Porter,
Springdale, Pa.

* * * *

In answer to W. E. H., I will say that it is necessary, if the generator is a shunt machine, to interchange the leads of either the armature or the field to cure his trouble. If the machine is a compound-wound generator W. E. H. should also reverse his series-field leads, should he decide to reverse the shunt-field leads. If the generator has an interpole winding and he should decide to interchange the armature leads he must also reverse the interpole leads or what is the same thing, but probably more convenient, the interpoles and armature connections can be reversed as a unit.

It may be necessary to separately excite the shunt-field winding in order to restore the residual magnetism in the right direction.

Ft. Dodge, Ia. CLAUDE D. MARTIN.

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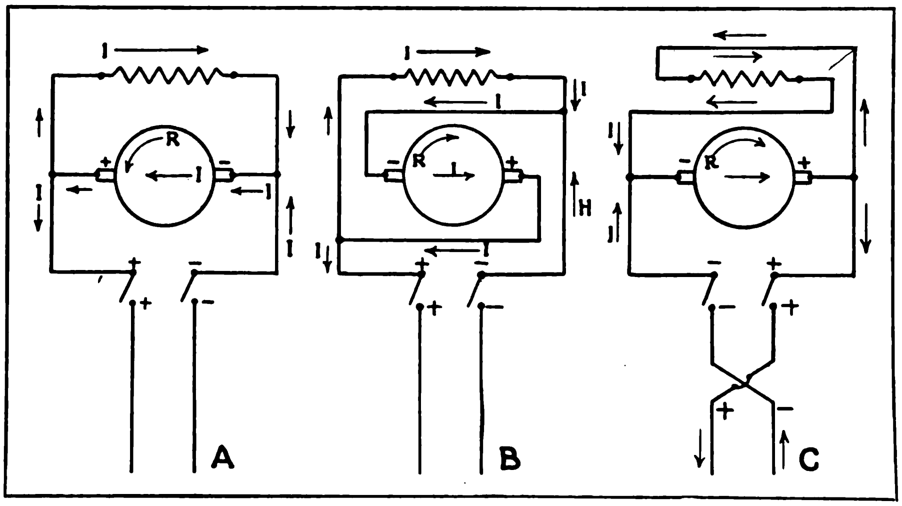
In answer to W. E. H.'s question regarding the low-voltage generator that will not excite itself, the fact that, after he rewound the shunt fields, the machine generated 55 volts satisfactorily proves that his rewinding is correct. The direction of rotation of the generator was then reversed and the machine would not generate.

To correct the trouble, simply change the polarity of the field connections with regard to the armature. In other words, reverse the field connections to the armature or brush holders. This machine should now generate the same voltage as before, providing the speed is the same. On account of the reversed polarity which might have been set up in the field cores previously, it may be necessary to excite the fields once, from the bus or a battery, so as to obtain a residual magnetism of the correct polarity to start the machine generating.

This is exactly the same proposition as reversing the direction of rotation of a d. c. motor. If the generator has



Relation of direction of rotation, armature polarity, and field polarity, in motors and generators.

At *A* is shown the relation of field current, *I*, armature current, *I*, armature polarity, and direction of rotation *R*, for a generator. To maintain the same status after reversing the direction of rotation of the armature, it is necessary to reverse the armature leads as shown at *B*. This change could also be made by reversing the field connections, as is shown at *C*.

to run in the opposite direction of rotation the connections between field and armature must be reversed.

GUY H. WINTERSTEEN.
Cleveland, Ohio.

* * * *

In answer to W. E. H.'s question, I would say that on any direct-current machine there are four conditions which can be changed. These conditions are (1) change from a generator to a motor, or vice versa; (2) change in direction of rotation; (3) change in armature polarity; (4) change in field polarity. If any one of the above conditions is changed, one of the three remaining conditions must also be changed in order to bring the machine back to the same status as it was originally.

In the case mentioned by W. E. H., the direction of rotation was changed. The natural thing to change with the direction of rotation was the flow of current through the armature. When the voltage started to build up, current began to flow through the field coils in the opposite direction to its flow before the change was made. This produced a magnetic flux in the field which was in the opposite direction to the residual magnetism in the field poles, thereby cancelling the same, and preventing generator from generating.

If the armature terminals that were connected to the brush holders had been reversed, the voltage would have built up without any difficulty, for in this case the direction of current through the field coils would not have been reversed to that formerly obtained and consequently, the residual magnetism in the field poles would not have been killed. This can be done as shown at *A* and *B* in the accompanying illustration.

Sometimes, it is not convenient or permissible to interchange the armature leads on the brush holders. In such cases the change can be made by reversing the connection of the shunt-field coil to the busbar leads, as is shown in *C* of the accompanying illustration.

Probably the easiest way of correcting the trouble that W. E. H. is experiencing, would be to change the direction of rotation of the generator by reversing the direction of rotation of the motor, thereby bringing the generator back to its original operating condition.

J. M. ZIMMERMAN.
Renewal Parts Engineer,
Westinghouse Elec. & Mfg. Co.,
Pittsburgh, Pa.

* * * *

Effect of Turning Rotor on Split-Phase Motors—I recently had to make repairs on some split-phase motors, and found it necessary to turn down the squirrel-cage rotors. I wish some reader would tell me what effect this would have on the motor characteristics, such as speed and capacity? Also, can some reader tell me how to reverse the direction of rotation on shaded-pole type motors? What is the rule for determining the direction of rotation on such motors?
Hood River, Ore. V. G. W.

Replying to question by V. G. W. about turning down the rotor of a split-phase motor, the actual effect would be to increase the magnetizing current because of the larger air gap. This increase would probably be noticed most at no-load operation. Such a condition may be compared to a transformer with loose joints in the air gap.

C. OTTO VON DANNENBERG.
Designing Engineer,
Sanderson & Porter,
Springdale, Pa.

* * * *

In answer to V. G. W.'s questions, I will consider each one in the order asked. The first and most important effect of reducing the diameter of the rotor is to enlarge the air gap, which increases the magnetizing current and decreases the power factor. Stray or leakage flux is also increased affecting the pull-out torque and tending to make the motor noisy in operation.

The net effect of reducing the diameter of the rotor is to decrease the full-load rating or increase the operating temperature, depending upon the total per cent change of flux density in the air-gap. Enlarging the air-gap 0.003 in. may cause an increase in no-load current of 5 to 10 per cent. It is hard to lay down any other rule than to advise against turning down the rotor any more than is absolutely necessary.

The only method of reversing the direction of rotation of shaded-type pole windings, is to turn the winding unit over end for end; that is, if both end bells are interchangeable, remove them and turn the rotor and stator around 180 deg. The direction of rotation will be towards the shading coil.

Wilkinsburg, Pa. A. C. ROE.

* * * *

In answer to the inquiry by V. G. W., turning down a squirrel-cage rotor will have a tendency to cause the motor to use a higher magnetizing current, which will lower the power factor, with a corresponding decrease in output. The starting qualities will be somewhat poorer and the pull-out point higher in proportion with a correspondingly lower speed.

The direction of rotation of shaded-pole motors is opposite to the end of the pole on which the shading coil is placed; that is, the shading coil is on the leading end of the pole. In changing the direction of rotation the shading coil is moved to the other half of the pole tip and automatically becomes the leading edge by virtue of the new direction of rotation. When changing the position of the shading coil too deep a cut will destroy all good characteristics of the motor, but a light cut will not effect the starting and stalling characteristics.

Newark, N. J. EDWARD JAMES.

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In answer to V. G. W.'s question, turning down the rotor of a split-phase motor increases the air gap, leakage flux, and magnetizing current, which in turn decreases the efficiency of the motor. However, this decrease will be small, depending upon the increase in length of the air gap. The slippage of the motor will be materially increased and the motor will accordingly run slower at full load. It will also pull out of step at a lower load than that for which it was originally designed. Unless this motor is overloaded, no appreciable difference should be experienced in its operation, if the double air gap is not increased more than 0.055 in.

The easiest method of reversing a shaded-pole motor is to remove the end bracket and turn the stator end for end, relative to the rotor. Sometimes it is more convenient to press the laminated core out of the frame with the field coils attached and turn it end for end with regard to the rotor. The rotation of the rotor will always be toward the shading coil.

The theoretical method of reversing the direction of rotation of this type of a motor is to shift the short-circuited starting coil to the other tip of the main pole. However, this is impracticable because it will be necessary to machine the slot to contain the shading coil.

J. M. ZIMMERMAN.
Renewal Parts Engineer,
Westinghouse Electric & Mfg. Co.,
Pittsburgh, Pa.

Electrical Service

around the works

For this section short articles describing ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing, and emergency or special installations.

Improved Method of Connecting Auto-Transformers For Lighting Circuits

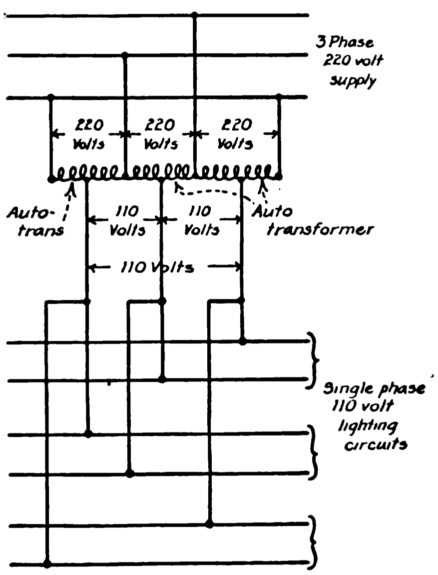
IN A GREAT many industrial plants the power supply is three phase, 220 or 440 volts, and the lighting supply is obtained from these power circuits by means of transformers connected thereto. It is quite common practice to connect an auto-transformer across one phase of the three-phase supply, the auto-transformer having a mid-tap, so that a 220/110-volt three-wire, single-phase supply is obtained. This system has several disadvantages, the more important of which are as follows: As all of the lights are connected to only one of the three phases, the lighting load unbalances the power circuit to a certain extent. A ground on the neutral wire in a three-wire lighting circuit is likely to disturb the equality of voltages in the three-wire circuit and may place as high as 220 volts across the 110-volt lamps.

In the connection scheme shown in the accompanying diagram, three auto-transformers are connected in delta across the three-phase power supply. Now, instead of using the line wires through the auto-transformer as well as the mid-taps, only the mid-taps are used to supply the 110-volt lighting circuit. The voltage between any pair of mid-taps is equal to the vectorial sum of half the voltage in the two auto-transformers to which the mid-taps connect. In other words, the resulting voltage equals $2 \times 110 \times 0.5 = 110$ volts. This is due to the fact that the two voltages are 120 deg. out of phase, thereby resulting in a voltage of only 110 volts.

With this connection scheme, three 110-volt, single-phase lighting circuits are obtained, which are 120 deg. apart in phase relation. By balancing the lighting load equally across these three single-phase circuits a good balanced load condition will be obtained.

An advantage of this connection scheme lies in the fact that grounds will not disturb the voltage on the different circuits and it is impossible to obtain overvoltage, thereby burning out lamps. However, it should be remembered that with this connection of auto-transformers it is quite easy to overload them, for in the more usual connection with a balanced load between the two outside wires of the three-wire circuit, the transformer is required to carry very little load, as practically no current flows through the neutral wire. With the connection scheme just described the total lighting load passes through the auto-transformers and due consideration should be given this fact when deciding upon the size of auto-transformers. However, I think that the elimination of overvoltage due to grounds will overbalance this disadvantage.

WM. P. AMANNS.
Chief Electrician,
Knoxville Iron Co.,
Knoxville, Tenn.



Use of this connection of auto-transformers on lighting circuits prevents danger of overvoltage due to grounds.

As may be seen, the feature of the connection lies in the fact that the lighting circuits are connected between middle points of adjacent auto-transformers which, due to the fact that the voltages in each transformer are 120-deg. out of phase, gives a voltage of only 110 volts.

Method of Using Flashlight For Testing Fuses

THE present-day, fused safety switch has a separate compartment for the fuses, the door of which cannot be opened until the safety switch is open. This is done for safety reasons, so as to prevent any one from changing or inspecting the fuses while they are alive. However, it prevents testing the fuses in the usual manner by shunting a test lamp across a pair of fuses while they are "hot."

To test the fuses that are used in a safety switch of this kind, it is necessary to remove them from the fuse blocks and test them with a magneto, or by connecting them through a test lamp with a source of power. At our plant we have devised a method of testing these fuses which is much more convenient and fully as reliable as the two methods just mentioned.

All of our motor inspectors carry small flashlights that have fiber cases. We have soldered a strip to the top connection of the switch on the side of the flashlight case; the other end of the strip is soldered to the metal band on the fiber case that screws into the cap, which holds the lens and the reflector. With this arrangement we are able to test a fuse by shorting it across the metal bands or ferrules at the top and bottom of the flashlight.

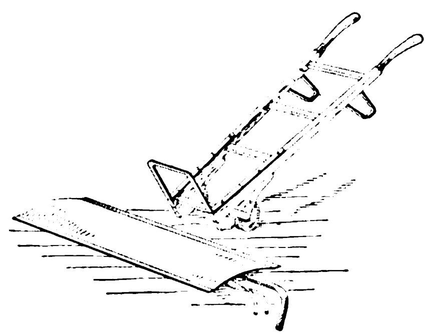
On some types of flashlights having fiber cases, the top and bottom caps or ferrules form part of the electric circuit that lights the bulbs. In such cases, if the flashlight should be laid down on a metal sheet, the light will burn even though the switch is off. With this type of flashlight the fuse may be shunted directly across the top and bottom ferrules and if the fuse is not burned out the flashlight will burn.

WM. B. CONE.
Chief Electrician,
Shevlin-Hixon Co.,
Bend, Ore.

Protecting Wire or Hose Lines Lying on Floor

IN THE use of portable electric or air tools it is often necessary to carry the lines across an aisle or other space where men are working or where trucking is necessary. Neither hose lines nor power wires will stand being trucked over without being damaged.

One method of protecting these wires is by the use of a special portable bridge, such as is shown in the accompanying illustration. This is made of sheet metal which may be of any thickness sufficient to stand the heavy or light traffic in the plant. A slight curve is made in this bridge to raise the center high enough so that air hose



This portable sheet metal bridge protects the electric power or hose lines for portable tools where they cross a passageway or aisle.

can lie underneath it without touching. The edges are bent so that they lie flat on the floor and also are beveled so as not to give an abrupt obstruction to the wheels of the truck. This bridge was made and is kept by the maintenance department and taken to any job where the men in this department find it necessary to use it.

Laying Conduit for Difficult Underground Installation

WHILE installing six white-way lamp posts recently near the entrance of a building, a local contractor had to overcome a very difficult problem of laying underground conduit. Two of the lamps were installed at the entrance of this building where a sidewalk 25 ft. wide was located and the other four lamps were placed equidistant along a 6-ft. walk leading up to the entrance.

In order to wire these lights, it was necessary either to cut through the concrete sidewalk or go under it. If the walk were cut through an ugly patch would be the result, along with the extra work and cost of making and repairing the break. The conduit required was ¾ in.; so it was decided to drive the pipe under the walk to eliminate digging a trench.

An iron spearhead 8 in. long and conical in shape, having a ¾-in. base which was threaded to fit into a ¾-in. sleeve, was made for this purpose. The sleeve and spearhead were then screwed into the length of conduit and driven with a hammer to where the earth was dug out to locate the concrete foundation for the post. The pipe was sawed off to the correct length after being driven through, and threaded with a ratchet die. This cutting operation also removed the battered end in each case without extra work. The spearhead fitting was reused in a similar manner to place the conduit required for each lamp. One length of conduit was lost in forcing it under the 25-ft. sidewalk and another was deflected by an obstruction, probably a rock. This length of conduit had to be removed with rope pulley blocks and a new location was tried with success.

In soft earth a pipe cap could probably be used to protect the threads on the driven end.

Heavy pipe a size larger than the conduit to be used, might be flattened on one end and used to make an opening in the ground. It could be cut off after being driven through and the conduit inserted which would make the process more costly, but more sure. This method would also be adaptable for installing steam or water pipes.

GRADY H. EMERSON.
Birmingham, Ala.

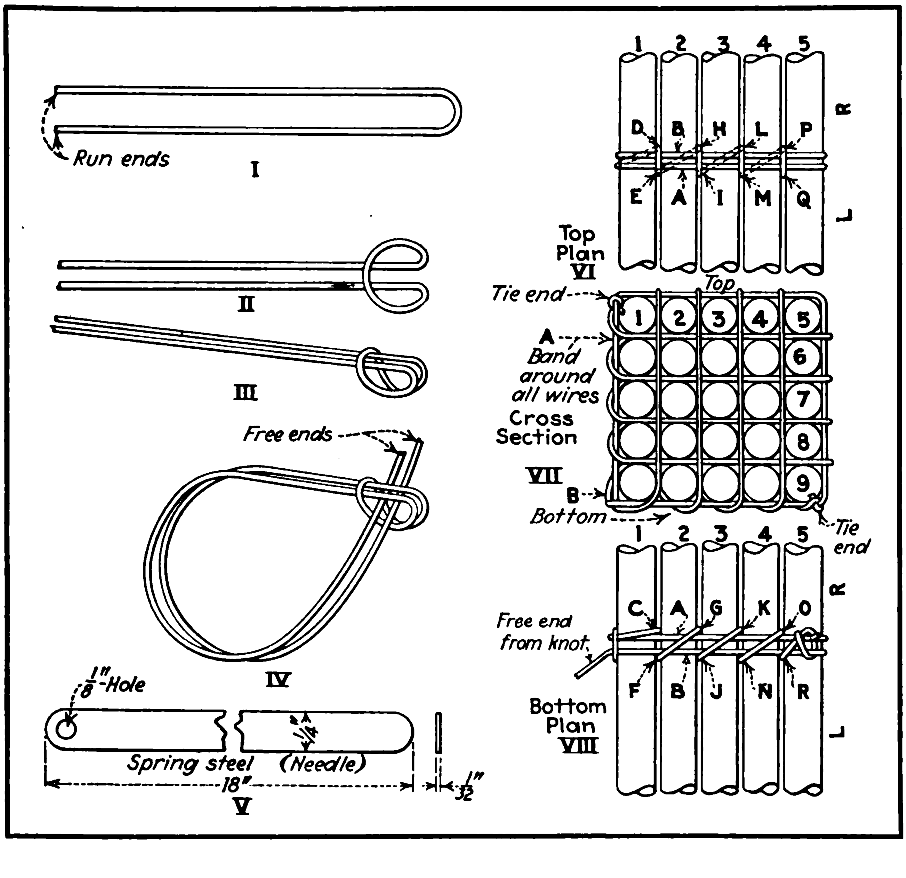
A Handy Stitch For Use When Tying Small Cables

WHEN wiring up switchboards and mounting resistance grids or controllers and so on, there are in most cases a number of small cables to be run and kept together in a neat and workmanlike shape. There is a stitch known as the "Chicago" which is used in running cables in telephone exchanges and keeps the cables square and neat in appearance, regardless of the number in the group. This Chicago stitch may be used to attach a group of cables firmly to an iron support, or used as a means to keep them lined up properly. When this stitch or tie is completed the cables can be hit with a sledge-hammer without knocking them out of line.

The first step in making this stitch is to cut a single length of cord long enough to pass around the cable group enough times to equal the number of cables wide multiplied by the number deep times two. For example in diagram *VII* of the illustration the cord is long enough to pass around the cable group 5×5×2=50 times, or the length of one turn multiplied by 50 is required. This single cord is doubled in half as shown in diagram *I* and folded back on itself, diagram *II*, forming an open loop on each side of the running ends. These two loops are then bent down on each side of the running ends as in diagram *III*. The next step is to hold these loops in one hand and with the other hand pass the free or running ends around the group of cables, through the sliding loop, as in diagram *IV*. When these loops and ends are pulled tight, they square up the cables at the same time.

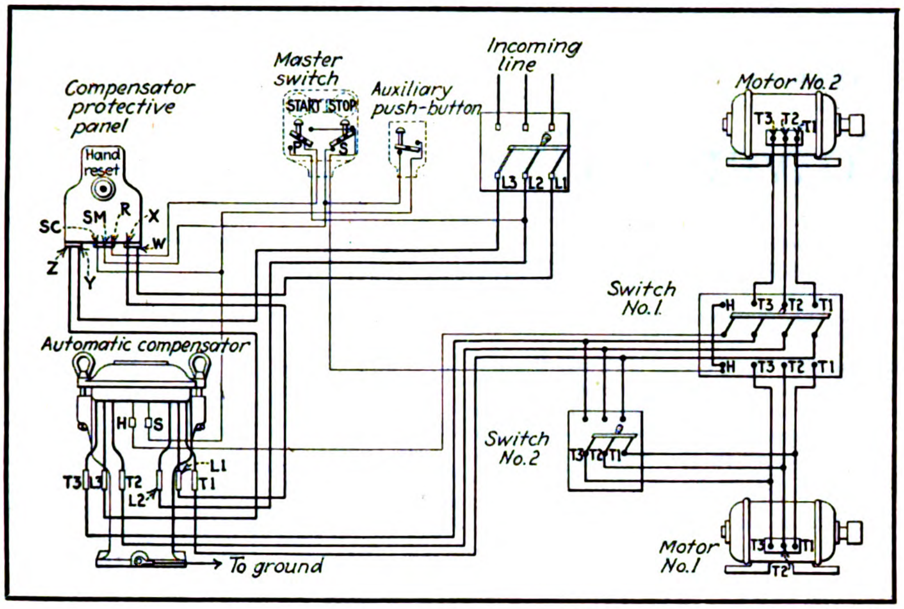
After tightening up the double cord band around all the cables there will be two long, free ends left hanging, one of which is shown in diagram *VIII*. The knot is made at the bottom to bring the free ends into a position to use. Selecting either free end of the cord to thread the steel needle shown in diagram *V*, the cord is brought up between the first and second vertical layers of cable on the right-hand side of band *A* at *C* in diagram *VIII*. (Note that left and right are indicated by *L* and *R* at the side of the diagram.) After pulling up all the slack and tightening the cord, the threaded needle is passed between layers *1* and *2* on the opposite or left-hand side of band *A*, or *D* to *E* in diagram *VI*. Crossing over to the right-hand side of band *A*, the needle is brought up between vertical layers *2* and *3*, as at *G* in diagram *VIII*. Thus a diagonal crossing is made from *F* to *G*; the cord comes up at *H* in diagram *VI* and is pulled tight. In the same manner the needle is passed over band *A*, down through layers *2* and *3* at the left of the band at *I* in diagram *VI*, with the cord coming out at *J*, diagram *VIII*. It is then passed over to *K*, up through layers *3* and *4* to position *L*, diagram *VI*. This operation is repeated until *R* in diagram *VIII* is reached, where the free end is fastened by the loop through a previous turn. In each case the cord is passed up and down between each vertical layer, being looped over the bands *A* and *B* top and bottom, and pulled up tight.

The above process is repeated with the other free end or band *B* except that the cord is passed through the horizontal layers, that is between layers *9* and *8*, *8* and *7*, *7* and *6*, and *6* and *5*. In making a study of diagrams *VI*, *VII*, and *VIII* it will be noticed that each cable is held with a double



Steps in tying cables with the Chicago stitch.

Diagrams *I*, *II* and *III* show how the cord is looped for sewing. The method of tying in the cables and the positions of the cords are illustrated in diagrams *VI*, *VII* and *VIII*.



Control connection scheme for using one compensator for starting two motors.

By means of transfer switch No. 1, the compensator may be connected to either motor for service duty. In case of fire when both motors must be operated at the same time switch No. 1 is thrown upward and switch No. 2 is closed.

cord band on all sides and so locked it is held solidly and firmly. If it is desired to attach the cables to an iron support the same method is used except that in the up and down or cross cable looping, the loop is made each time around the iron support. Suppose for example that the iron support was on the bottom in diagram *VIII;* when passing from position *F* to *G*, the loop would be made around the iron support. For light and springy cables the tie bands should be spaced 12 in. apart; for rigid wires such as solid, fireproof, or insulated, the bands should be spaced 18 in. apart.

This is a simple stitch to apply after the method of procedure has been acquired and will be found handy around power stations, industrial plants or in any place where a number of cables or wires are grouped and run for any distance.

Wilkinsburg, Pa. A. C. ROE.

Automatic Switching Simplifies Use of Pumps for Fire and Service Duty

WHEN water is needed to fight a fire, is no time to think of sparing the motors that drive the pumps. They must do their duty, even though they may be seriously overloaded. What is a motor or two compared to the thousands of dollars worth of equipment which will be endangered if they stop running?

With this thought in mind, the electrical department at the Newcastle plant of the National Radiator Company have installed a system whereby the service pumps have the combined duty of furnishing service water and fire protection. When these pumps are at work during a fire, nothing but a power failure or burned-out motor can stop them.

Two Deming triplex-pumps, each driven by a 15-hp. motor, alternate on the job of supplying high-pressure water for testing the castings for radiators and boilers. One of these pumps is sufficient for this service, so that the other serves as auxiliary equipment. An Electric Controller & Mfg. Co. 15-hp. automatic compensator, provided with a switch, is used to start either of these pumps by means of a push button. The operating motor is protected against overloads by a protective panel which opens the motor power supply circuit through the compensator.

The diagram shows the scheme of connections. When motor No. 1 is being operated for pumping water for test service, switch No. 1 is in the downward position and switch No. 2 is open. Motor No. 2 may be operated similarly by throwing switch No. 1 upward and leaving switch No. 2 open. Thus it is seen that switch No. 1 is simply a means of transferring from one motor to the other.

Twice a month, fire drills are held at this company's plant, and every man is trained to perform his duties in an efficient manner. At the pump station there is great activity when the fire whistle sounds, for one pump is in operation and may be supplying water for test work. So the first thing the man assigned to the pumps must do is to shut down the pump, close the valve leading to the test department, and open the one which parallels the two pumps on the fire system.

The problem is to start both pumps at once with two 15-hp. motors connected to a single 15-hp. compensator. It is quite evident that this is a decided overload; so the overload protective panel must be cut out before the starting button is pressed. This is done by an auxiliary push button which cuts out this panel and permits the motors to operate continuously at any overload. Normally, this push button is locked so that the protective panel cannot be cut out accidently. Switch No. 2 is closed and switch No. 1 is thrown upward for paralleling the two motors through the one compensator and when the start button is pressed, they are brought up to speed automatically. From that time on these pumps will continue to run until the stop button is pressed or until trouble causes the motors to fail.

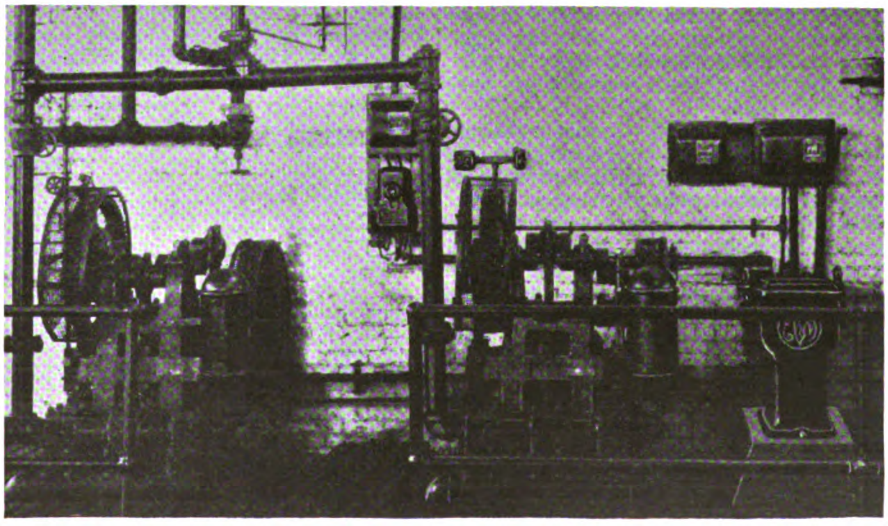
A feature of this switching arrangement is that it is entirely fool-proof. Should the operator fail in the confusion of a fire to shut down the pump on service duty before he attempts to parallel the two motors on the line, throwing of switch No. 1 to do this paralleling, automatically disconnects the motor which is operating on the line. Then when the start button is pressed the two pumps are brought up to speed at the same time through the use of the automatic compensator.

L. S. MONROE.

The Electric Controller & Mfg. Co., Cleveland, Ohio.

Only one compensator is required for starting the motors which operate the two pumps shown here.

Two 15-hp. motors connected to a single E. C. & M. 15-hp. automatic compensator are operated in parallel in case of fire to drive two Deming triplex pumps. Normally only one motor and pump are required to supply water for testing and other purposes.



Mechanical maintenance of part Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through the auxiliary transmitting equipment to all driven machines.

Using Auto Tire Dust Caps as Oil Cups on Motors

OIL cups are an absolute necessity on a motor using the cup and wick oiling system. However, it is often rather difficult to replace these oil cups when they become lost, and suitable substitutes which may be obtained easily may come in very handy as it is not good practice to leave the oil hole open, particularly in dusty locations.

Dust caps from automobile tires make excellent oil cups and are of the proper size for most small motors and fans. If a thread-cutting lathe is not available, turn or file a slight taper at the open end of the cap, so that it can be started into the motor and saw a slot lengthwise through the tapered portion. If the cap is screwed up tightly it will stay in place and give good service.

Durant, Okla. J. P. KINCAID.

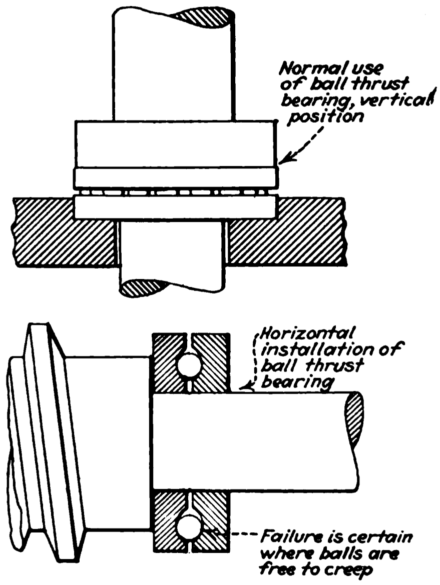
Improper Use of Thrust Ball Bearings on Worm Causes Trouble

THRUST ball bearings are not so commonly used as are radial ball bearings. Unless full consideration is given to the detail construction of the bearings and the manner of mounting, the bearing may fail apparently without cause. One such case was in connection with a ball thrust bearing on a worm drive. The worm was mounted horizontally with radial ball bearings and in addition thrust ball bearings were used at each end to take the worm thrust. Every few weeks, the thrust bearings would fracture or the balls would break. According to the manufacturer's ratings for the bearings, they were of sufficient capacity to sustain the thrust loads which were imposed on them.

After considerable experimenting, one of the engineers suggested that the balls in the bearing be mounted in a cage to prevent their shifting position. When this was done the bearing trouble ended immediately. Manufacturers generally recommend the use of a cage or retainers to space the balls properly and keep them in position. Many times, however, attempts are made to apply balls without such a retainer.

The explanation of this trouble described above is that a thrust bearing, when mounted with the ball race horizontal, will operate without any difficulty. When it is placed on edge, or in other words with the axis horizontal, the balls creep between the sections of the races when the screw is reversed, causing the races to separate. This causes the balls to be caught out of position when the load is again reversed and applied on the thrust bearing. The lowest ball then carries the major part of the load and either or both the ball and races fail. The use of a cage maintains the alignment of all the balls in their proper positions, distributes the load uniformly and so prevents further trouble from such sources.

Washington, D. C. G. A. LUERS.



How the thrust load is applied on vertical and horizontal ball races.

When a thrust ball bearing is used on a horizontal shaft the balls may be crushed, as shown in the lower drawing, unless a cage is used to retain the balls in their proper position. The conditions are different with vertical thrust and loads, as indicated in the upper drawing.

Simple Puller for Removing Solid Pulleys From Old Shafting

HAVING occasion recently to dismantle the pulleys and shafting in an old plant, we found it necessary to rig up a special device for loosening the solid hubs of the pulleys from the shafts. The device shown in the accompanying sketch was used.

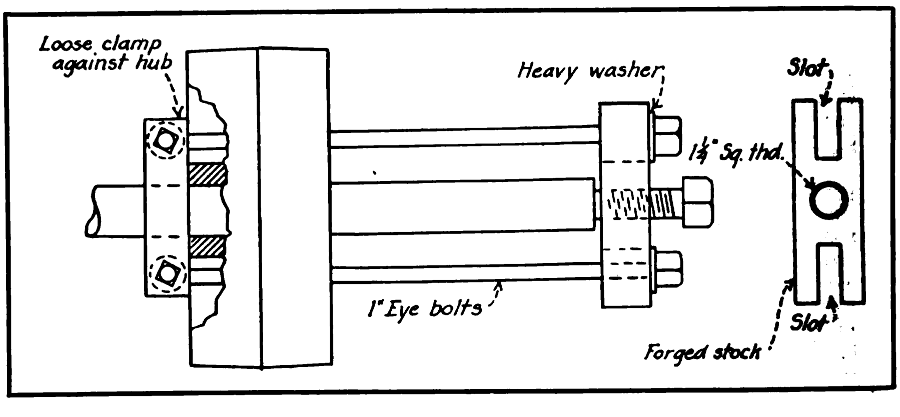
This puller was to be used on shafts of different diameters; so the clamp which fits behind the pulley was made up of two ⅝-in. by 3-in. pieces of bar steel and bolted together so that the edges of the bars fitted against the hub of the pulley. Eyebolts were inserted as shown. These eyebolts were made of 1-in. round steel, 5 ft. long, and were threaded for about 4 ft. It happened that all of the pulleys were within 4 or 5 ft. from the end of the shaft. These eyebolts could have been made any length desired.

A piece of 3-in. by 4-in. forged steel stock about 6 in. long was slotted at the ends. A hole was drilled in the center of this and tapped for a 1¼-in. square screw thread and a bolt made to fit. This slotted bar is shown at the right in the sketch below.

The clamp was placed around the shaft back of a pulley hub and the nuts on the eyebolts placed in the slots with large washers under the nuts. The bolt with the square thread was then tightened against the end of the shaft.

Previous to doing this the shaft around the hub was well soaked with kerosene; then it was tapped with a hammer as the pulling force was applied with the screw. In some cases it was necessary to heat up the hub

Solid-hub pulleys were easily removed from shafts with this puller, when dismantling an old plant.



with a torch to expand and loosen it from the shaft, although in most cases the pulleys were loosened by the screw and then pulled along the shaft by the nuts on the eyebolts. This device more than paid for the time and material used in its construction by the saving in time which it made possible.

Hollywood, Calif. M. C. COCKSHOTT.

Discussion of Use of Belt or Chain Drives for Woodworking Machines

IN NO other industry, probably, are the advantages of the individual drive so generally recognized as in connection with woodworking. The product is so bulky that a re-arrangement of machines independent of lineshaft restrictions may represent such savings in materials handling costs, maintenance charges, floor space, and power costs that the cost of a new installation or of the rearrangement of an old one is completely wiped out in a few months.

The machine room in a steam-driven "planing mill" was a fearsome place; the whole building shook with the pulsations of the machines and shafting, and overhead hangers, shafts, and pulleys were deeply coated with oil and dust. Back of many machines about 10 ft. of space was railed off for the jackshaft serving that machine and from which several belts drove various heads and feeds. Contrast such conditions with that of the accompanying illustration, which is a good example of a modern mill that has kept the same machines but applied individual drives to them.

Each of the machines that appears in this illustration has gained in floor space and, instead of a large area taken up by the drive there is only that occupied by the motor. Also, power is used only when needed.

Whether to use belt or chain drive from the motor is often a problem. No better way to decide this can be found than to put in a few drives of each kind and watch the performance and costs through a period of years. If the chain is to be left exposed to woodworking conditions, it will not give more than a fraction of its normal years of service. A belt stands up better in the dust and chips, although these will dry out and crack any belt if it is continually neglected.

In the immediate foreground, a 1,500-r.p.m., 10-hp. motor is shown driving an American outside molder. This driving speed is reduced to 800 r.p.m. on the jackshaft through 25- and 47-tooth sprockets. The Morse chain is ½ in. pitch and 3 in. wide. One of the advantages of chain drive is that it permits the use of close centers. In this particular case, the shafts are 18 in. apart and could have been made closer if it had been necessary. It would not be practicable to run belts with such small pulleys, and larger pulleys would have been impossible on account of interference. So long as odd numbers of teeth are used in the sprockets to prevent links running in the same teeth all the time, there is no hard and fast restriction as to close centers, although it is well not to go closer than four times the diameter of the small sprocket.

A belt-driven saw, which is also shown in this illustration, is connected up to operate at double the speed of its 1,500-r.p.m. driving motor. In this case a 4-in. belt is used. An automatic idler insures the proper driving tension. The motor is mounted on a sliding base which is used to take up the belt stretch; the chain-driven motor also has a sliding base, although it might have been eliminated.

The saw was belt-driven because of the difficulty of covering the upper sprocket of a chain drive so that it would be protected from cuttings and also because it was not easy to remove the shrunk-on pulley from the arbor and put on a sprocket instead. The installation is an example of good practice.

Except in some unusual locations, the use of an idler is an admission of the inadequacy of the particular belt drive. In this case, as with most saws, the driven pulley is small and the idler does increase the arc of contact, besides adding to the tension of belt on the pulley. However, all these benefits are at the cost of increased bearing friction. If a belt drive will not pull the saw, the most logical plan is to increase the width of pulleys and belt; this can be done for a cost as low as that of the idler. On installations where the idler is used for taking up the stretch in a belt, instead of cutting and lacing or cementing, it functions as a take-up and its use is justifiable, in the writer's opinion.

For use on drives where a small diameter pulley or sprocket and close clearance are unavoidable, chains may prove the solution in spite of their apparent handicap. A belt is thin and it will wrap itself around a small pulley very easily. On the other hand, a chain of the proper pitch will also conform to small diameters and, as its driving ability does not depend upon friction, the small diameter may usually be decreased enough to permit the outside of the chain to come within the same clearance without any sacrifice of pulling power.

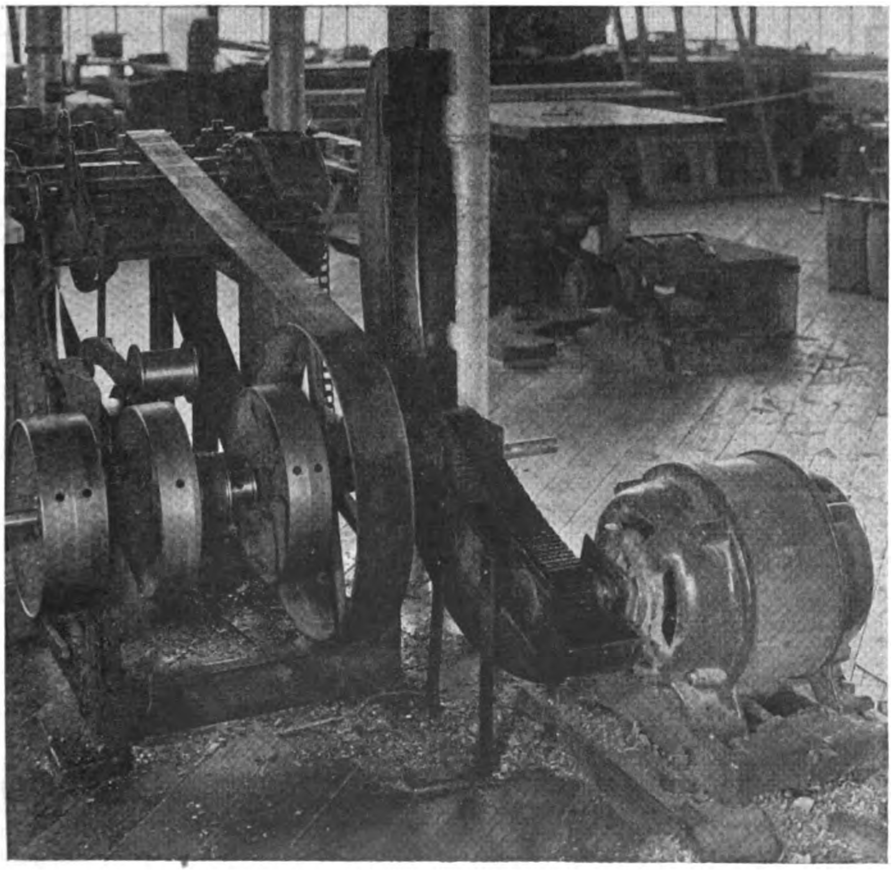
The writer has successfully used small sprockets on saws with small-diameter, high-speed shafts. Where a separate sprocket would be too large, new arbors have been used and the teeth cut integral on the new parts.

As shown in the illustration, a substantial cover has been built around the chain drive. This cover has a hinged top, which permits inspection and lubrication without requiring the use of any tools which might fall inside. Industrial men who have placed covers equally as good about their short-belt drives have also been amply repaid, as the life of belts which are well cared for is about as long as that of chains. DONALD A. HAMPSON.

Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Because of the high speed at which woodworking machines operate the selection of the drive is of especial importance.

This illustration shows how a silent chain and a belt were used on different woodworking machine drives. In one case the speed is stepped down, and stepped up in the other. Additional interesting considerations concerning these drives are discussed in the accompanying item.



In the Repair Shop

This section is devoted to repair work on electrical and mechanical equipment. Special attention is given to shop or bench tools and short cuts or improved methods of handling work of this character. Contribution are always welcome.

Proper Method of Cleaning Dirty Storage Battery Boxes

SOME very interesting information as to the proper method of cleaning storage battery boxes was given in a recent issue of *Pullman News*. It seems that the Pullman Company has discontinued the practice of cleaning batteries with water. It was found that the practice of washing out battery boxes at the time batteries are flushed or when an accumulation of foreign matter has collected, is responsible to a large extent for many leaky cells found in service. Such leaky cells are caused by the electrolytic action of the current flowing between adjacent cells or crates and woodwork of the box, to grounds caused by wet and acid-soaked crates and battery boxes.

A battery box should not be washed out except when it is especially dirty or acid-soaked, in which case it is advisable to neutralize the acid with a soda solution and then wash out with a flushing hose. It is impossible to wash acid out completely with plain water, particularly when the acid has penetrated the woodwork.

When neutralized by a soda solution as described above, all traces of acid are removed and the box will quickly dry after washing. Care should be taken when flushing to prevent cells from being over-flushed.

Simple Device for Rewinding Blowout Coil

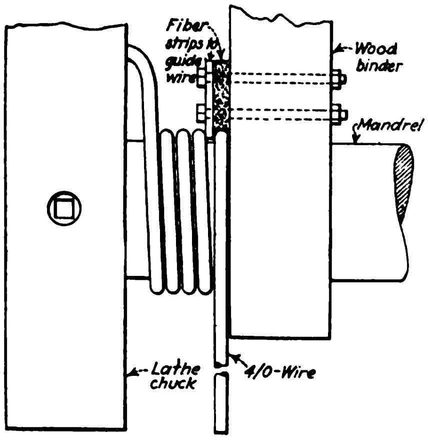
WHILE repairing a 200-amp. circuit breaker, it was discovered that a blowout coil had become crystallized in a flashover and was so brittle that it fell apart in dismantling the breaker. This breaker was of an old type and a new coil could not be obtained in less than 60 to 90 days. So ways and means of making another coils were considered in order to avoid this extra delay.

The coil consisted of 12 turns of ½-in. round, bare copper, with an inside diameter of 2¾ in. We found that a local supply house could furnish us with 9 ft. of the No. 4/0 wire which we required. No. 4/0 wire has a diameter of 0.46 in., which was close enough.

An old piece of shafting was placed in the lathe and turned down to 2¾ in. for a distance equal to one and one-half times the coil length. For this operation the tailstock of the lathe was run back and the shaft held in the chuck on the headstock. A block of maple was cut 2 in. by 6 in. by 18 in. and a 2¾-in. hole bored at one end of the maple block, so that it could be slipped over the shaft. A piece of ½-in. fiber was fastened by bolts to one side of this block ½ in. above the hole. A strip of ¼-in. fiber was then placed over the ½-in. fiber and allowed to project slightly, forming a groove for the turn being wound on, as shown in the illustration.

The wood binder or maple block was put on over the mandrel or shaft and one end of the copper wire was fastened to the chuck. A quarter of a turn was made with the wood binder; then the lathe was turned over a quarter of a turn and this was repeated until the 12 turns were wound. Holding the mandrel in the lathe chuck provided good control over the winding process and prevented backlash and loose turns, which would otherwise be a hindrance to winding.

The coil was insulated with one, half-lapped layer of treated cloth tape and one, half-lapped layer of 0.007-in. cotton tape and then dipped in liquid Bakelite and baked. The last two turns at each end of the coil were reinforced with an extra layer of cotton tape. When the tape was applied to the turns, the coil was sprung open and then pressed together before dipping.



The coil of No. 4/0 wire was formed around a mandrel by means of a maple block which was slipped over it.

Two pieces of fiber fastened to the side of the block form a projection with a groove which serves to bend and guide the wire.

Considering the crude tools used, the quality of the coil was good, combined with the features of neat appearance, quick delivery, and low cost.

Wilkinsburg, Pa. A. C. ROE.

Changing Speed and Horsepower of Induction Motors

IN MOST industrial plants, owing to the many changes in equipment, it is often found necessary to decrease or increase the horsepower of induction motors. The two instances cited below are typical problems of this character.

One case involved a 100-hp., 60-cycle, 1,200-r.p.m., 550-volt, three-phase induction motor direct-connected to a 10-in. centrifugal pump. This pump was taken out of service and a hydraulic pump for a different service was then installed, which required a 50-hp. motor operating at about 700 r.p.m. It was decided to change the speed of the 1,200-r.p.m., motor so that it could be used on the new pump.

The horsepower output of the motor at the changed speed was checked first since the horsepower increases or decreases in direct proportion and in the same direction as the speed, if the voltage also is changed. With a decrease in speed from 1,200 to 720 r.p.m., which is the nearest synchronous speed to 700 r.p.m., the motor would develop $(100 \times 720) \div 1{,}200 = 60$ hp.

As this horsepower was near enough to that required, more data were carefully obtained. The stator contained 72 slots and 72 coils; the pitch was 58 per cent of full pitch. The coil sides were placed in slots *1* and *8*, while full pitch would be, 72 (slots) $\div$ 6 (poles) $=$ 12. The chord factor at full pitch, or 12, equals 100 per cent and is also the sin of one-half the angle covered by the coil throw. The span is 180 deg., which at full pitch is 180 deg. $\div 12 = 15$ deg. per slot. The throw of 1-and-8 covers seven slots; $7 \times 15 = 105$ deg., and the sin of one-half of 105 deg. or 52.5 deg. equals 0.79 which is the chord factor of the winding. The original winding is shown in Fig. 1 *A*.

The next important item considered was the pitch with the changed connection. The motor was originally connected for six poles, or 1,200 r.p.m., while the new connection for 720 r.p.m. would be $7{,}200 \div 720 = 10$ poles. Full pitch with ten poles equals 72 (slots) $\div$ 10 (poles) $= 7.2$. Since the original winding pitch was 1-and-8, 7.2 was near enough to consider the changed winding as being full pitch or practically 100 per cent chord factor.

The motor was to be used on 550 volts, as before; so the effect of the change in speed would be to reduce the counter emf. from 550 to $(720 \times 550) \div 1{,}200 = 330$ volts. However, 550 volts was the original impressed voltage with a chord factor of 79 per cent, and since

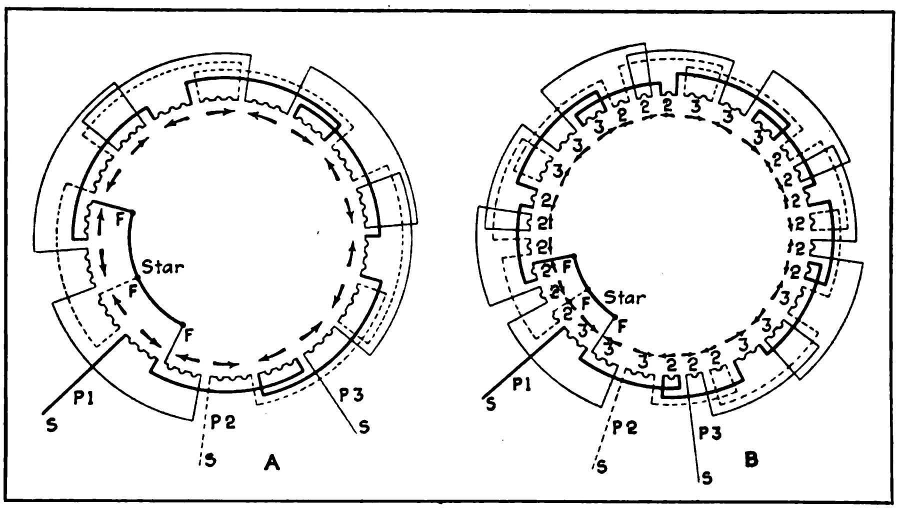


Fig. 1—The speed and horsepower of this induction motor were decreased by changing the coil grouping and number of poles.

In diagram *A* is shown the original winding of 72 coils, connected series star for six poles, equal grouping, four coils per pole-phase group. Diagram *B* shows the new ten-pole winding consisting of 72 coils with unequal grouping, connected series-star. The figures indicate the number of coils per pole-phase group.

the new chord factor was 100 per cent, the counter emf. would be (100×330) ÷79=417.7 volts, which was much lower than the impressed voltage, but it was decided to reconnect the motor.

The original winding had 72÷(3×6) =4 coils per pole-phase group, while with the new connection, this would be 72÷(3×10)=2.4. This made the new connection one of unequal groups, or numbers above and below 2.4. We decided to use 18 groups of two coils each and 12 groups of three coils each, making a total of 72 coils, which was the required number. The motor was then connected series-star, as originally, but for ten poles, and put into service. When driving the pump only, the ammeter reading was 70 amp., at 55 per cent power factor. We had no way of exactly obtaining the efficiency; so this was assumed as 87 per cent, and with this factor as a basis we figured that the pump required (0.87×70×0.55×550×1.73)÷746=42.5 hp.

There were two agitators that required about 15 hp. to drive them; so it was decided to drive these from the pump motor lineshaft and save the cost of a 15-hp. motor. This was done and the ammeter reading increased to 85 amp. at 65 per cent power factor. Assuming the efficiency at 88 per cent, the horsepower output was (550×85×0.65×0.88×1.73)÷746=62 hp. There was a slight unbalance of current in the different phases and the power factor of the motor was lower than it was with the original winding, but this was to be expected, since the speed was lower. As the horsepower of the motor was reduced, the carrying capacity of the windings was not considered.

This motor has been in operation for eight months, carrying its load constantly 24 hr. each day with no heating above normal and has given entire satisfaction. Diagram *B* of Fig. 1 shows the connections after the change.

The other case was that of a 10-hp., 600-r.p.m., three-phase, 60-cycle, 550-volt induction motor, which was connected by a belt to a gas blower. The speed of the blower was 950 r.p.m., and it was desired to increase the speed to 1,150 r.p.m., in order to obtain proper combustion in a sulphur burner. This meant that the motor speed would have to be about 700 r.p.m. Assisting this blower was an exhaust blower driven by a 10-hp., 1,200-r.p.m. induction motor. The latter fan was not economical, as it wasted considerable gas.

The first point considered was the power output, as the greater fan speed indicated that the horsepower of the motor would have to be increased. Theoretically speaking, a change from 600 to 720 r.p.m. would increase the motor output to (720×10)÷600=12 hp.

The next point considered was the carrying capacity of the winding. On examination it was found that the coils were wound with No. 12 d.c.c. wire and the connection of the complete winding was series-star. No. 12 d.c.c. wire has a carrying capacity of 25 amp., but the full-load current of a winding is equal to the line current divided by 1.73 and in this case equaled, 12÷1.73=6.9 amp., so that there was ample carrying capacity for the starting current even if it were four times normal full-load current. The details of the winding are shown in Fig. 2 *A*. On further investigation it was found that the stator had 108 slots and 108 coils with a pitch of 1-and-9. Full pitch would be 108÷12=9, so that the chord factor of the winding was 0.985, for 180 (deg.)÷9(slots)=20, and the sine of one-half of (20×8) deg.=0.985. Connecting for 720 r.p.m. required 7,200 (alternations) ÷720=10, or a 10-pole connection. Full pitch for this connection equals 108÷10=10.8. This left the coils in the same slots and gave them a chord factor of 0.916 when connected for ten poles, since 180 deg.÷10.8=16.6 and the sine of one-half of (8×16.6) deg=0.916.

With the increase in speed, the generator action of the motor, with the old winding, would increase the required voltage to (720×550)÷600=660 volts, but since the chord factor was decreased from 0.985 to 0.916 the voltage would be reduced to (660×0.916)÷0.985=613 volts.

In connecting the winding for ten poles, unequal grouping was again encountered, since 108÷number of poles× number of phases, 108÷(10×3)=3.6; some groups would thus consist of three coils and others of four coils. Figuring the coils per pole-phase group gave 18 groups of four coils each, or 72 coils, and 12 groups of three coils each, or 36 coils, making a total of 30 groups and 108 coils. The winding was connected series-star as shown in Fig. 2*B*.

When this motor was again placed in service, the full-load speed was 690 r.p.m., while the speed of the fan was 1,140 r.p.m. The starting torque of the motor was increased. Likewise, the pressure of the gas was increased enough to enable us to dispense with the 10-hp. fan mentioned above. The full-load current taken by the motor was 14 amp. at 80 per cent power factor and with an efficiency of 88 per cent, the full-load rating was 12.5 hp.

H. E. STAFFORD.
Electrical Engineer,
Provincial Paper Mills, Ltd.,
Port Arthur, Ont., Can.

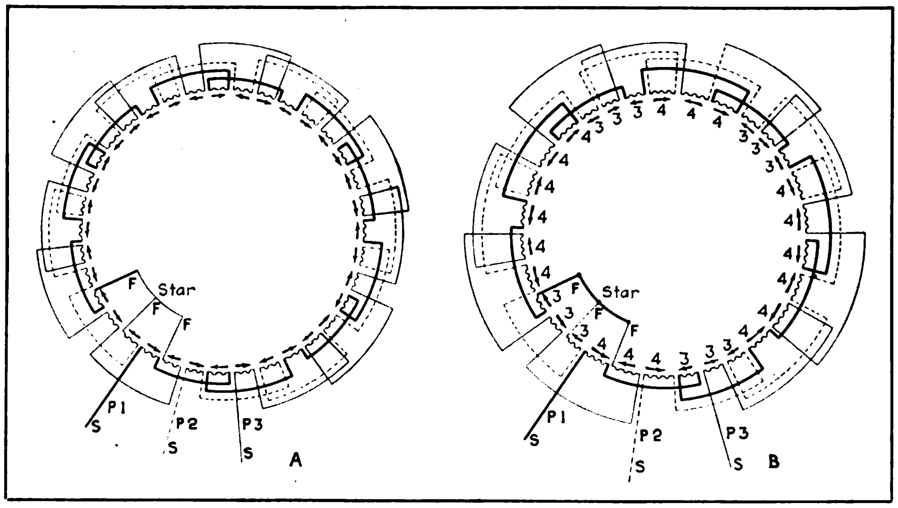


Fig 2—In this case the speed and horsepower of the motor were increased.

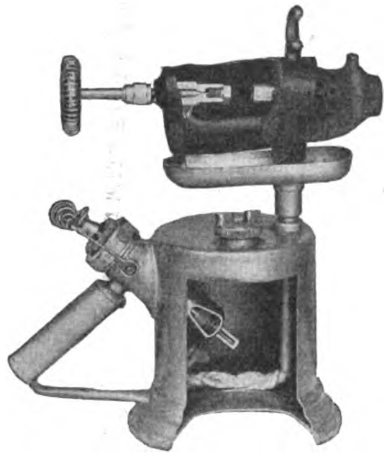
Diagram *A* shows the original winding of 108 coils connected series-star for 12 poles, equal grouping, three coils per pole-phase group. The motor was rewound, as shown in *B*, for ten poles, 108 coils connected series-star, unequal grouping. The figures indicate the coils per pole-phase group.

New Equipment
for plant operation and maintenance

Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these new devices which are designed to improve plant operation or reduce operating and maintenance costs.

New Gasoline Blowtorch

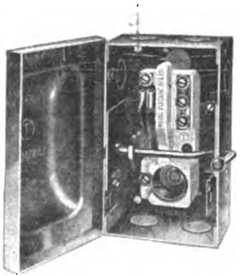
THE accompanying illustration shows the construction of the operating parts of the new Wall Dreadnaught No. 41 blowtorch. Some of the advantages claimed for this new



torch are: It can be supplied to burn kerosene or gasoline; it produces a bigger, broader flame; every time the valve is opened or closed, the orifice is automatically cleaned by a needle, which is easily removed and replaced if damaged; it is impossible to enlarge the orifice or damage the valve seat. It is also equipped with a special burner patterned after the Wall furnace burner. Other features, common to all Dreadnaughts, it is stated, include seamless steel tank with bottom and all connections brazed with hard brass spelter solder; fuel economy; long life and absolute safety. This is made by P. Wall Mfg. Co., Pittsburgh, Pa.

Single-Blade, Single-Fuse Enclosed Switch

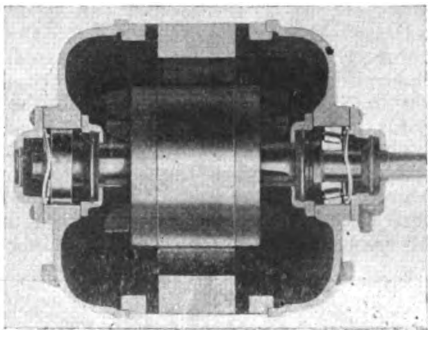
PRODUCTION is announced by The Trumbull Electric Manufacturing Co., Plainville, Conn., on the E. W. (easily wired) single-blade, single-fuse, enclosed switch which is designed to be used in places where it is now the practice to use heavy-duty snap switches and separate cut-out boxes on branch circuits. This switch is compactly enclosed in a box, 6 in. by 3 11/16 in. by 3⅝ in., with a hinged cover. It is stated that removing two screws permits the switch base and operating handle to be lifted from the box as a unit, which facilitates installation. This switch is intended for use in any 125-volt, two-wire branch circuit carrying a current of 30 amp. or less, or as a single-fuse entrance switch. Some of the general uses are: starting motors up to ¼ hp.; for entrance work; for controlling heavy-duty lighting circuits; and on domestic or industrial heating devices.



This switch is totally enclosed and provided with holes in the catch for seals or padlocks. Concentric knockouts for ½-in. and ¾-in. conduits are provided in the sides, ends and back. It is stated that ample wiring space is provided on all sides and under the switch.

Automatic Rotor Recentering Bearings for Motors

TO INSURE uniform air gap in motors, the Howell Electric Motors Co., Howell, Mich., has brought out a complete line of motors with anti-friction bearings, in which, it is stated, any looseness in the bearing, caused by wear or otherwise, is instantly and automatically taken up, so as to keep the rotor of the motor continually centered with a uniform air gap. This is accomplished by the use of a Timken taper roller bearing, shimmed with a



fluted wire spring, as shown in the accompanying illustration, which acts as a compression spring.

The inner race or cone of the Timken bearing is fitted on the shaft with a light press fit. The outer race or cup is fitted into the housing of the motor end bell with a sucking fit which allows creeping of the outer race. The spring is held tightly against this outer cup by the outer grease cap; this pushes the cup tightly against the rollers and keeps the bearings tight at all times.

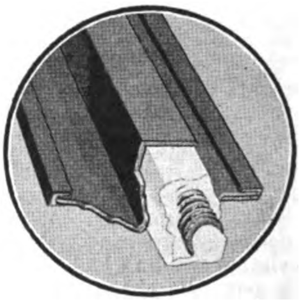
This type of bearing is put in each end of the motor and accomplishes the following, according to the manufacturer: (*a*) Keeps the rotor automatically centered at all times, and thus keeps the air gap uniform. (*b*) The spring allows for any lateral expansion of the shaft which might occur due to heat. (*c*) The spring keeps the bearings tight at all times. (*d*) It causes the bearing to run more quietly.

These bearings are arranged for grease lubrication and seals are used to keep the grease in and to keep out foreign matter. These motors can be mounted in any position, without changing the end bells; also, they will operate in the vertical position, it is said, as well as horizontally, as these bearings have a thrust capacity equal to their radial capacity.

These motors with Timken tapered roller bearings are offered by this company in all types and sizes, in addition to their regular rotor recentering sleeve bearing.

Electric Space Heater

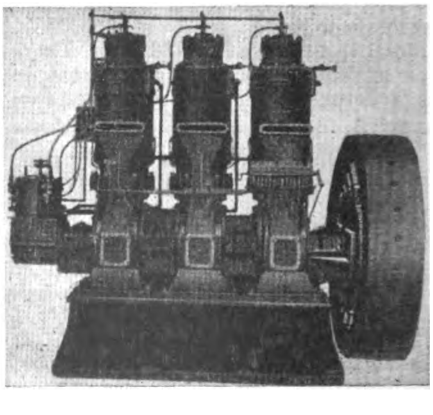
ANNOUNCEMENT is made by the Cutler-Hammer Mfg. Co., Milwaukee, Wis., of an improved design of space heater. The heating coil, as shown in the accompanying illustration,



is imbedded in a protecting and radiating material of improved refractory quality, according to the manufacturer. These heaters are 2 ft. long and may be installed singly, in pairs, or in groups. It is stated that this new type of heater is easier to install and has increased heating efficiency. This heater may be used in crane cabs, isolated watchmen's houses, garages, sprinkler system valve houses, japanning ovens and for various other purposes.

Flywheel Type Alternators for Engine Drive

THE Ideal Electric & Manufacturing Co., Mansfield, Ohio, which recently brought out a new line of motors called the "Flywheel Type," are now in a position to furnish this as an engine-type alternator or self-contained power unit. Because the



alternator is an integral part of the engine, it occupies less space than the old conventional design and does away entirely with any generator foundation and erecting, as shown in the accompanying illustration.

The manufacturer states that with the same rotor weight, the flywheel effect of the flywheel-type alternator is nearly twice that of the present-day design. If extra heavy flywheel effect is desired, the rotor can be provided with a double-rim section.

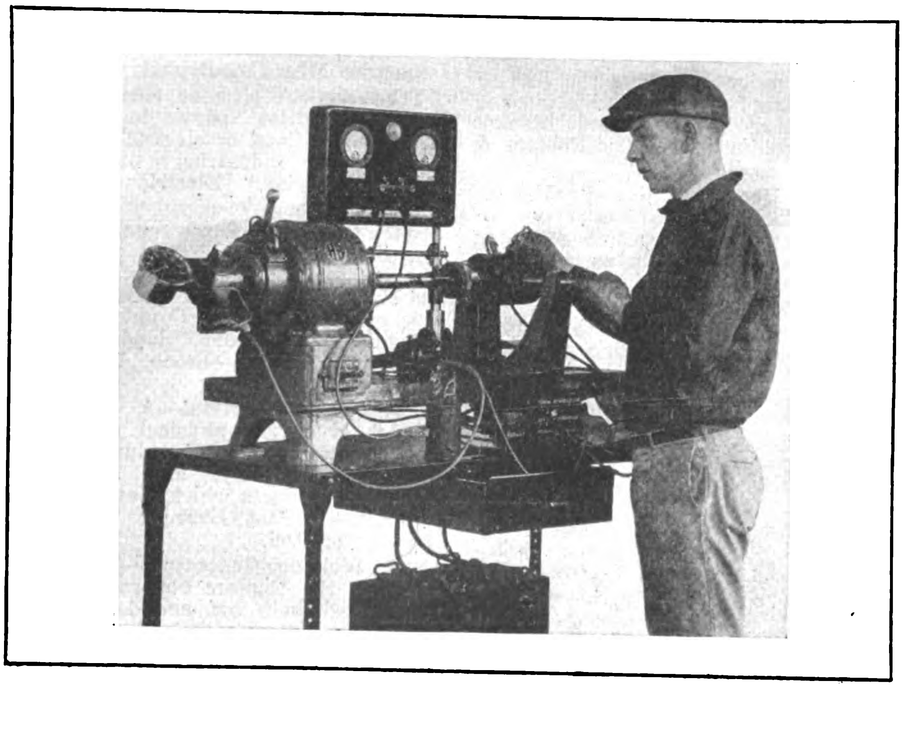
This type of alternator adapts itself admirably to the "overhung" type without auxiliary flywheel, and the problem of incorporating the necessary flywheel effect in the alternator rotor has merely become a question of bearing limitations. It is stated that the air gap is always correct and uniform and will stay so during the life of the machine. An exciter or any auxiliary machine may conveniently be belted to the flywheel rotor, thus saving an auxiliary pulley.

Electrical Test Bench

ELECTRICAL test bench illustrated is being manufactured by the Hobart Brothers Co., Canal Lock Square, Troy, Ohio, for locating troubles and testing out automobile starting motors, generators or other electrical equipment.

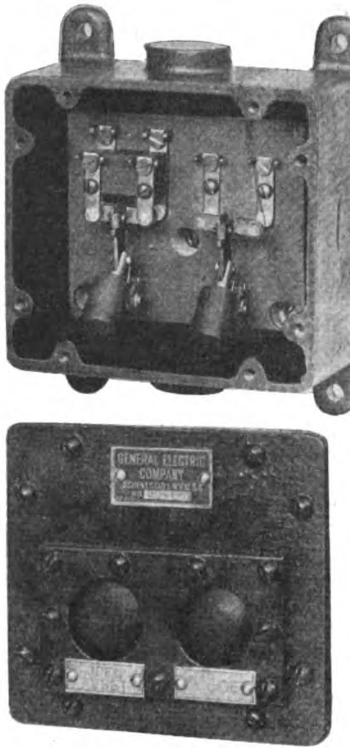
The test bench is equipped with a 1½-hp. Hobart, reversible, variable-speed motor. A tachometer indicates the motor speed. The set has a two-point spark gap and a rotary spark gap graduated in 360 deg. A silent flexible coupling is used between the motor and the chuck which has an adjustable flexible mounting. The vise is designed to handle all sizes and types of automotive generators, starting motors, and similar small equipment.

The switchboard is of Bakelite and the switches are all of the inclosed tumbler type. Test sockets with external leads and a condenser with in and out plugs are provided. The ammeter has a range of 30-0-30 and 600-0-600, while the voltmeter has a 0-25 range. It has a 110-volt test lamp and a complete fixture for testing torque.



Dust-Tight Push Buttons

WHERE dust-tight, enclosed, magnetic starting switches are used on a.c. circuits, a specially designed push-button station is often employed. The device shown in the accompanying illustration was originally designed by



the General Electric Co., Schenectady, N. Y., for marine use, and the push button was mounted under partial cover on deck where it would occasionally be subjected to a spray of water. To obtain the necessary protection, a cast-iron case is used with a flexible leather gasket over the push buttons.

Each button is operated by pressing on the leather directly over it. The leather is very flexible and may be kept in that condition by occasional applications of neatsfoot oil. The push-button station can be mounted either vertically or horizontally and is dust-tight.

New Fire Extinguisher

THE Rego Fire Stopper, manufactured by the Bastian-Blessing Co., 240 East Ontario St., Chicago, Ill., is intended for use in garages, power stations, industrial plants or private buildings.

This type of extinguisher is composed essentially of two parts: a cylinder to hold compressed carbonic acid gas and a cone to be filled with powder. In use, the valve in the tank is opened as much as may be necessary. The escape of the gas creates a whirling action in the cone and projects the powder through the nozzle in a stream that has a range of about 25 ft., according to the manufacturer.

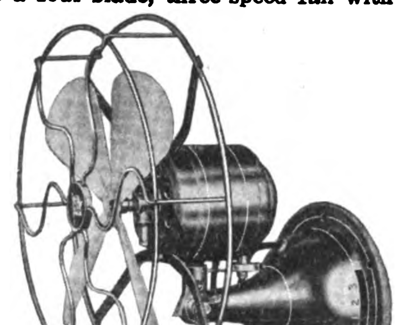
The carbonic acid gas has a smothering effect on the flame, it is stated, while the powder, when it comes in contact with the flame, decomposes into carbonic acid gas and water or steam, and any remaining powder will blanket the flame in much the same manner as would a similar amount of sand. Tests are said to have shown that the powder is a non-conductor of electricity and can be used against electric fires on circuits up to 160,000 volts without danger to the operator.

Advantages claimed for the extinguisher are that it can be stopped at any time while in operation and can be used again without recharging and leaves no injurious by-products.

The cone has a capacity of 2 gal. or 17 lb. of powder and the apparatus weighs 32 lb. when charged.

Oscillating Bracket Fan

THE accompanying illustration shows a Model 46, 10-in. a.c. oscillating fan announced for 1926 by The Robbins & Myers Co., Springfield, Ohio. This is a four-blade, three-speed fan with a



drawn-steel frame. The motor is of the induction type for 50 or 60 cycles only and of the shaded-pole type. The gear mechanism is integral with the rear head bracket and is fully enclosed within a removable end cover. It is stated that this fan makes five complete oscillations per minute over 75 deg. or can be made non-oscillating.

Trade Literature

you should know about

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Arc Welding Supplies—Section 1611 is an 8-page catalog covering the line of Lincoln arc welding supplies, which include cables, shields, welding electrodes, aprons, gloves, brushes, electrode holders, and other accessories used in repair, structural, or production work.—The Lincoln Electric Co., Cleveland, Ohio.

Worm Gearing—Bulletin 105 gives interesting data on standard worm mountings on various centers as well as gear ratios available on those centers, dimensions of standard gears and flanged gear rims, as well as several applications of Cleveland worms and gears and speed-reduction units.—The Cleveland Worm & Gear Co., 3258 E. 80th St., Cleveland, Ohio.

Crane and Derrick Hoists and Drives—Catalog 84 illustrates and describes the line of Shepard crane and derrick hoists, back-geared electric motors, speed reducers, and industrial, contractors' and hauling winches. Numerous installations are illustrated.—Shepard Electric Crane & Hoist Co., Montour Falls, N. Y.

Repair-Shop Equipment—A 14-page booklet describes various pieces of repair-shop equipment particularly adaptable to automotive and other light electrical repair work.—David W. Onan, 43-51 Royalston Ave., Minneapolis, Minn.

Speed Reducers—A 16-page bulletin illustrates with cross-section views and describes the DeLaval line of worm and single and double helical speed reducers.—DeLaval Steam Turbine Co., Trenton, N. J.

Slip-Ring Induction Motors—Bulletin 137 illustrates the construction, describes the operation, and shows by charts the operating characteristics of the Wagner wound-rotor, slip-ring polyphase motors, which are built for two- or three-phase circuits in sizes from ¼ to 300 hp., for 110 to 2,300 volts, and for all commercial frequencies.—Wagner Electric Corp., St. Louis, Mo.

Non-Metallic Gears—A 24-page booklet gives engineering data and describes a number of industrial applications of Celoron gears.—Diamond State Fibre Co., Bridgeport, Pa.

Time Switches—Catalog 4, Section 1, describes the electric, motor-driven States time and distance switches which may be set for automatic control of the operation of any electric circuit or device on a fixed time schedule.—The States Co., Hartford, Conn.

General Catalog—The new General Catalog, 6001 B, which is issued every two years, contains 1,100 8-in. by 10½-in. pages with over 3,200 illustrations. The catalog is thumb-indexed into 16 sections as follows: generation, wire and cable, distribution transformers, arresters, voltage regulators, switchboards and accessories, meters and instruments, motors, motor applications, industrial control, railway, lighting, industrial heating, and miscellaneous. Products are also indexed by subjects and by catalog numbers.—General Electric Co., Schenectady, N. Y.

Gasoline Soldering Irons—A circular describes the gasoline Ever-Hot combination branding and soldering blowtorch and various types of tips which may be used in connection with it.—Combination Blow Torch Mfg. Co., 2809 W. Van Buren St., Chicago, Ill.

Lubrication—A monthly bulletin under the above heading discusses the selection and use of lubricants for various types of equipment. For example, the December, 1925, issue was on "Lubrication of Materials Handling Equipment."—The Texas Co., Dept. H, 17 Battery Pl., New York City.

Manual Controllers—Bulletin 100 describes the new Clark manual controller which is of the faceplate type, built for heavy-duty service, and is suitable for electric traveling cranes, charging machines, mill tables, or any other applications where reversing of the motor is necessary and where hand operation is suitable. This is made in ratings of from 1 to 25 hp. at 110 volts, and proportionate ranges for other voltages.—The Clark Controller Co., Cleveland, Ohio.

Countershaft Bearings—A folder describes the use and life of the Arguto oilless bearings on countershafts.—Arguto Oilless Bearing Co., Wayne Junction, Philadelphia, Pa.

Induction Motor—A 26-page catalog describes the Linc-Weld induction motor, its construction and special features. This motor is made of steel parts welded together and is built for standard a.-c. voltages from 110 to 2,300 volts, for two- or three-phase, and 25, 30, 40, 50 and 60 cycles in sizes from 1 to 500 hp.—The Lincoln Electric Co., Cleveland, Ohio.

Fans—Catalogs describe the line of R & M electric fans, both oscillating and non-oscillating in wall and bracket types and ceiling type.—The Robbins & Myers Co., Springfield, Ohio.

Electric Heating Units—Booklet C-100 describes the various types of Chromalox electric heating units in convenient forms for industrial heating.—Edwin L. Wiegand Co., 422 First Ave., Pittsburgh, Pa.

Conduit and Fittings—Catalog 10 is both a catalog and a wiring guide for the use of Wiremold conduit system for surface wiring. The various fittings are cataloged and illustrated and sketches and diagrams show how they may be connected up.—The American Wiremold Co., Hartford, Conn.

Materials Handling—Circular 7378 under the above heading discusses the advantages obtained in various industries through the use of electrically-driven machinery for the handling of material, gives information and data covering the principle groups of materials handling devices, and describes Westinghouse electrical equipment developed especially for materials handling machinery.—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Speed Reducer—A circular describes the Lipe speed reducer, which is a ball-bearing, planetary unit with a flexible coupling built in on the low-speed shaft. These reducer units are built in two types for reduction from 4 : 1 to 100 : 1 and from 48 : 1 to 7,000 : 1 up to maximum ratings of 500 hp.—W. C. Lipe, Inc., 208 S. Geddes St., Syracuse, N. Y.

Electric Industrial Trucks—A 40-page bulletin illustrates, describes and gives specifications for various types of Crescent trucks, tractors and other special storage-battery equipment. Numerous applications in different plants are illustrated.—The Crescent Truck Co., Lebanon, Pa.

Non-Metallic Gears—A booklet describes and discusses Formica silent gears, gives data on the horsepower ratings, and instructions for their use.—The Formica Insulation Co., Cincinnati, Ohio.

Across-the-Line Switch—A circular illustrates a number of applications of the J-1552 across-the-line starter for a.c. motors, lists the advantages claimed, and shows the construction.—Allen-Bradley Co., Milwaukee, Wis.

Hand Lift-Trucks—The 16-page Bulletin 101 describes Models F and G Barrett hand lift-trucks and shows applications in a wide variety of industries.—Barrett-Cravens Co., 1328 W. Monroe St., Chicago, Ill.

Flexible Couplings—A folder describes the Falk-Bibby flexible couplings and illustrates their operation under light and normal loads and severe overloads. This coupling is manufactured in capacities ranging from ⅛ to 20,000 hp. at 100 r.p.m.—The Falk Corp., Milwaukee, Wis.

Hand Lift Truck—A circular describes the new Cowan Blue Streak self-loading hand lift truck which has roller-bearing wheels with Alemite lubrication. This type is built in various sizes of platforms and diameter of wheels, but only in 2,000-lb. capacity.—Cowan Truck Co., Holyoke, Mass.

Ball-Bearing Motors—A circular gives some interesting figures stating how an annual saving of 20.9 per cent on the investment was made on a ball-bearing motor installation.—The New Departure Mfg. Co., Bristol, Conn.

Tramrails—A circular entitled "Mr. Keen Kompetitor" shows installations of Cleveland hand or electric tramrails in a variety of industries in 42 different plants.—Cleveland Electric Tramrail Co., Wickliffe, Ohio.

Wire Catalogs—Three separate catalogs illustrate and describe, give ratings and specifications of various types and sizes of Rome wire. These catalogs are entitled, "Bare Copper Wire," "Magnet Wire," and "Super Service Cord and Cable."—Rome Wire Co., Rome, N. Y.

Non-Corrosive Metal—A 40-page booklet gives the physical properties and characteristics of Everdur, a corrosion-resistant alloy, and illustrates numerous products which may be made from it.—DuPont Everdur Co., Inc., Wilmington, Del.

Arc Welding Generator—A circular describes the Dualarc generator which can furnish both a.c. and d.c. current for carbon or metallic arc welding.—Electric Arc Cutting & Welding Co., 152-156 Jelliff Ave., Newark, N. J.

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Founded 1882 as
The Electrical Review

April, 1926

McGraw-Hill Publishing Co., Inc.
Chicago Ill.

Development Directed Far Forward

In latest Allis-Chalmers induction motors, all-around efficiency leaps ahead in the traditional Allis-Chalmers way. Now it is possible to operate normally without inspecting or lubricating more than every few months under even the worst conditions. Yet initial clearance may be expected to last for the life of the windings!

15% less over-all length is obtained, on the average, for a given horsepower output. Rigidity and drive layouts are therefore markedly improved. At the same time starting characteristics are bettered because the lubricant is instantly available.

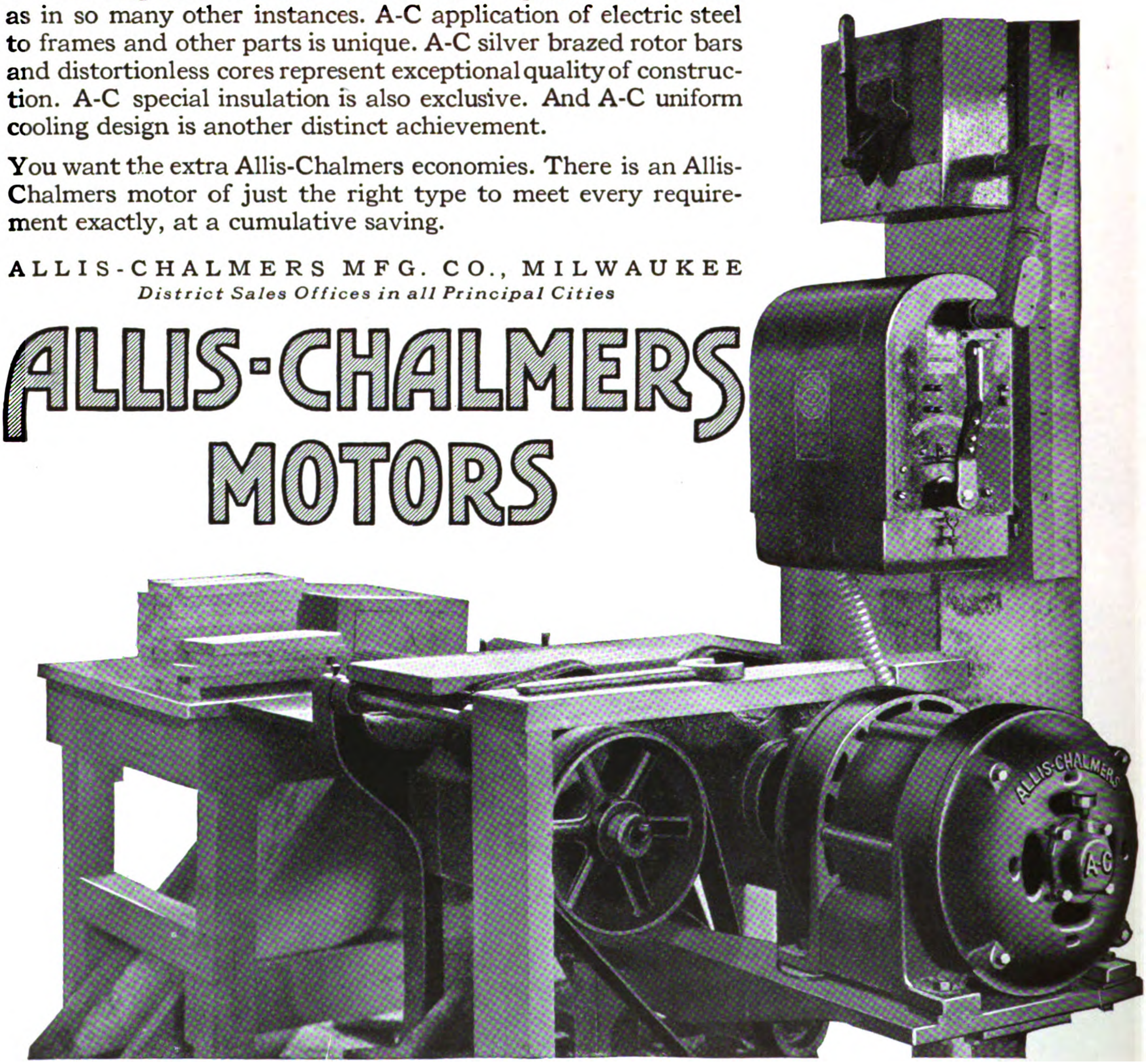
Underlying these results is the Allis-Chalmers application of Timken Tapered Roller Bearings. In the anti-friction field Allis-Chalmers again directs electric motor development far forward, as in so many other instances. A-C application of electric steel to frames and other parts is unique. A-C silver brazed rotor bars and distortionless cores represent exceptional quality of construction. A-C special insulation is also exclusive. And A-C uniform cooling design is another distinct achievement.

You want the extra Allis-Chalmers economies. There is an Allis-Chalmers motor of just the right type to meet every requirement exactly, at a cumulative saving.

ALLIS-CHALMERS MFG. CO., MILWAUKEE
District Sales Offices in all Principal Cities

ALLIS-CHALMERS MOTORS

Allis-Chalmers Motor 15 h.p., 3600 r.p.m., Timken-Equipped, Direct-Connected to Mereen-Johnson Cleater



INDUSTRIAL ENGINEER

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James H. McGraw, Jr., *Vice-Pres.-Treas.*

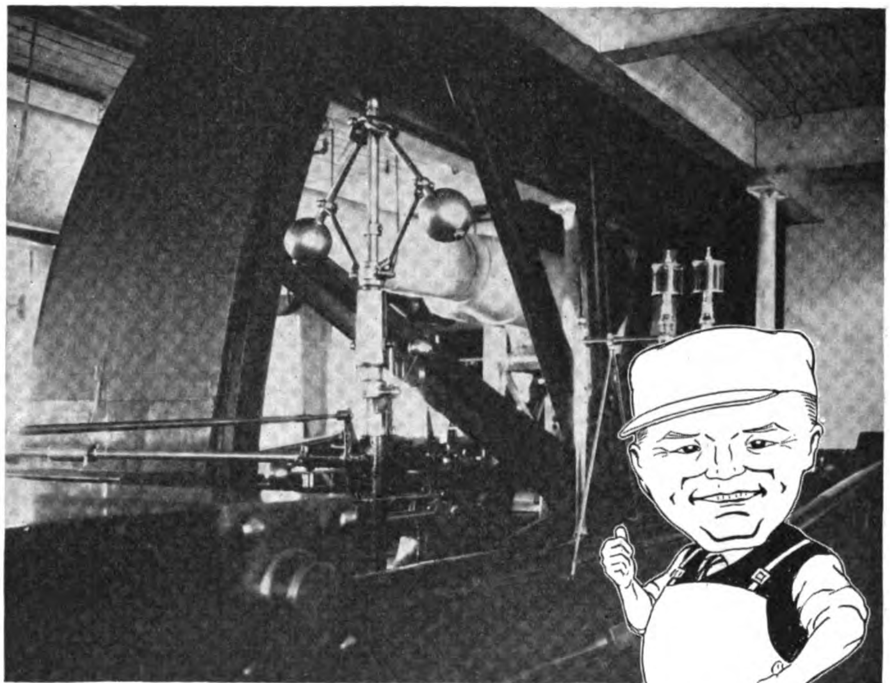
Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

G. A. Van Brunt, *Managing Editor*

Volume 84 Chicago, April, 1926 *Number 4*

What Is the Age Limit for a Leather Belt?

while one swallow does not make a summer, the data on this belt deserve your attention



I DO not know of any one thing that brings more genuine satisfaction these days than to find that you have obtained your money's worth on a purchase. On the other hand, there is nothing more irritating, especially to an engineer, than to be "stung" by a just-as-good article purchased on the basis that some manufacturers' representatives are better salesmen than liars.

The things I have in mind now revolve around the service furnished by the 42-inch, three-ply leather belt shown in this picture. This belt was installed on a Corliss engine drive in the Brenon Mills at Georgiaville, R. I., in November, 1876, and was in continuous service until the latter part of 1925. It has outlived its maker, the owners of the mill, and the engineers who installed it. During this period of around 49 years, and after 35 years of service, the only repairs were the removing of the inside ply and the addition of a new ply to the outside. This belt has run over a 30-ft. driving pulley and a 7-ft. pulley on the driven shaft. It was originally installed to transmit 500 hp. with the driving pulley operating at 45 r.p.m., but after a few years the speed was increased to 61 r.p.m., giving a belt speed of 5,740 ft. per minute with a driving tension under normal load of 110 lb. per inch of belt width. The belt tension was certainly up around the top limit of accepted practice, if not from 10 to 20 lb. higher than good belt men usually recommend. Besides, the centers measured 31.5 ft. All of these elements, combined with a pulley ratio of more than 4 to 1, did not favor long life for a belt of this size.

A little simple arithmetic shows that the owners of this belt purchased a prize package. The belt cost when new, in 1876, was $1,317.03. The cost of the new ply in 1911 was about $600. Last year when it was discarded it brought $300 making the total cost of this belt $1,617.03.

Some more interesting sidelights on belt depreciation with age have resulted from tests on sections of this belt. The minimum strength of six sections when it was cut up was recorded as 1,870 lb. per sq. in. The maximum strength of the same number of sections was 2,850 lb. per sq. in., making the average around 2,400 lb. per sq. in. On the basis that a new belt of the same quality would have a breaking strength of 5,000 to 6,000 lb., it can be assumed that the old belt depreciated in strength about 50 to 60 per cent during 49 years of service, but even under such depreciated strength, the material was stronger when discarded than the greatest tension that could be applied to it as a belt.

Here are some real facts about a leather belt that should be tucked away and thought about when the question comes up of whether to buy or not to buy a first-grade leather belt. I am not going to ask you to take my word for the accuracy of the figures presented, but refer you to Mr. Louis W. Arny, Secretary of The Leather Belting Exchange at Philadelphia, Pa., who can tell you a whole lot more about this belt drive.

Practical Pete

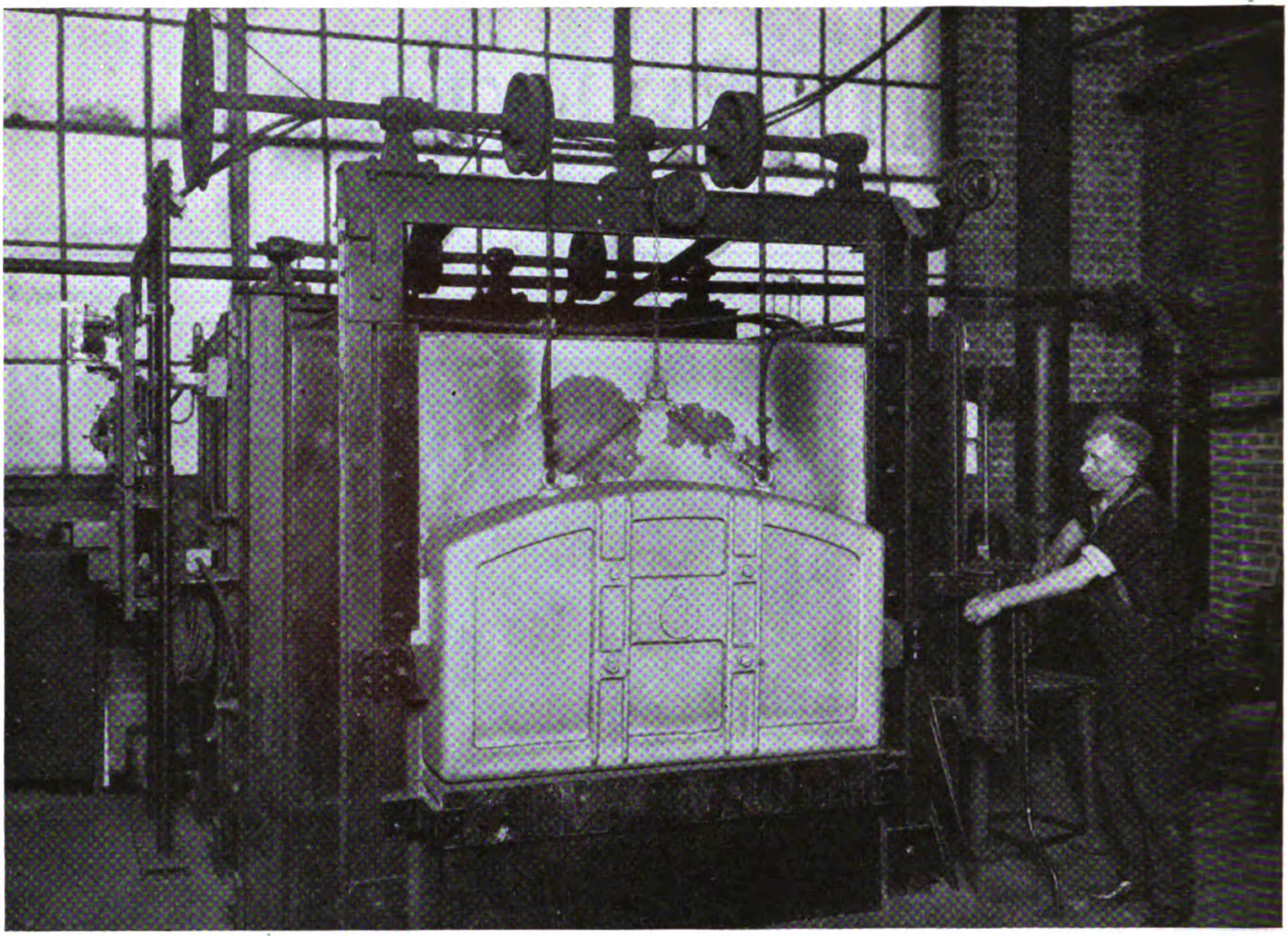


Fig. 1—Standard box-type electric furnace for annealing, hardening, carburizing and other heat treatment processes.

This furnace is rated at 50 kw., 220 volts, three phase and has inside dimensions of 4 ft. wide, 4 ft. deep, and 2 ft. high. It is capable of giving temperatures ranging from 750 deg. to 1,830 deg. F.

Applying Electric Heat in Industrial Plants

together with a discussion of the application of bulk heating, localized heating, and heat treatment processes, including worked out examples that will aid in solving industrial heating problems

By N. R. STANSEL
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THE application of industrial heating can be divided into three fairly well defined classes. In the first class fall those processes in which the form or the character of the raw material is changed and which are also characterized by a low unit value of product, no requirement of exact control of temperature, and bulk of material predominating. Examples of this class are the melting of metals, burning brick, manufacture of cement, evaporation of moisture and similar heating operations.

In the second classification falls the use of heat for local applications, either as individual units, for glue pots as illustrated in Fig. 10, melting pots for alloys, compounds, space heaters and the like and also where the heating unit is built into the machine as in the several types of machinery used in shoe making (one of which is illustrated in Fig. 11), the line casting machine for casting lines of type used by printers, the paper box machine and similar applications. There are a multitude of applications of this kind.

The third class embraces all heating processes in which an even distribution of heat and close control of temperature are essential factors in the success of the use of heat to change the character of a material. The heat treatment of steel, annealing of non-ferrous metals, vitreous enameling, annealing of glass, baking bread, and the like, represent this class as distinguished from the more simple applications of heat to raise the temperature of substances to some approximate value.

In the first class, which can be termed "bulk heating," fuel is, as a rule, the economic source of heat. In some cases it is practicable to use electric heat. This, however, depends upon the nature of the application and the comparative costs of fuel and electric energy. It is in this class that the cost of heat units is the important factor. While on the whole, electric heating, for a long time at least, will be in the minority in bulk heating, there are numerous

applications of electric current in this class on an economic basis. For example, the heating of buildings in the Northwest and in some countries of Europe, the production of steel in the electric furnace, the melting of non-ferrous metals and alloys on a large scale, water heating, and similar applications, all of which indicate the possibilities of electric heat in this first class of heat utilization where conditions make desirable its use.

In general it can be stated that under present day conditions, bulk heating by electric current is not an economic method until the cost of electric energy begins to approach, on a descending scale, one cent per kw.-hr. This, of course, depends on the cost of fuel in any particular locality in which an application of electric heat is desired.

The use of localized heat is particularly the field of the smaller electric heating units. These are made in three principal forms, namely, cartridge units, clamp-on units, and immersion heaters. Here easy divisibility, convenience of application, freedom from effects of vibration, safety, cleanliness, and similar characteristics, of electric heating units, all combine to make electric current an effective and economical method for localized heating.

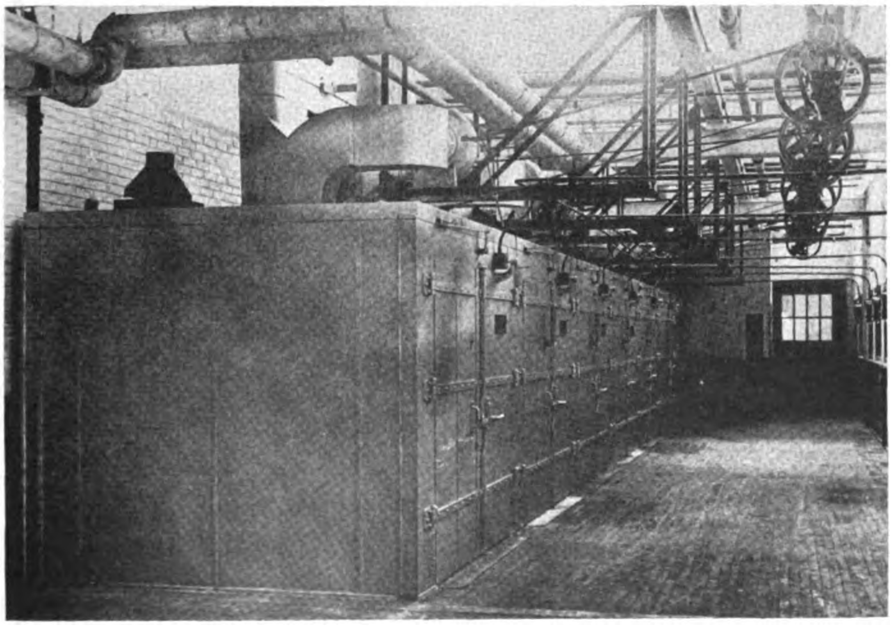


Fig. 2—Cleanliness is a characteristic of electric heat.
This fact is illustrated by this picture of a battery of seven general japanning ovens at the plant of the Ritter Dental Co., Rochester, N. Y. The connected load of each oven is 42 kw. and is operated from a 220-volt, three-phase, 60-cycle power supply and supplies a range of temperature from 150 to 450 deg. F.

In the third class of heating defined in the foregoing as heat treatment processes, the approximate temperature classification is as fol- temperature classification is as given in the following tabulation:

OVENS	
Drying	Up to 300 deg. F.
Baking varnishes, colors	150 deg. to 300 deg. F.
Baking black varnishes	400 deg. to 500 deg. F.
Baking bread	400 deg. to 500 deg. F.
FURNACES	
Annealing non-ferrous metals	700 deg. to 1,400 deg. F.
Annealing steel	Up to 1,600 deg. F.
Hardening steel	Around 1,500 deg. F.
Carburizing steel	1,500 deg. to 1,700 deg. F.
Annealing glass	Up to 1,200 deg. F.
Vitreous enameling	1,600 deg. to 1,800 deg. F.

While this tabulation gives a general idea of temperatures used for various heat treatment processes, it must be kept in mind that the actual temperature to be used depends upon the material and upon the time during which heat is applied. In other words, for each material and for each process, even in drying, there is some one temperature, or some combination of temperature and time, which will give the best results. With a lower temperature than this value the desired result from heat treatment is not realized. A higher temperature than that necessary in any given case introduces the risk of overheating and in addition is a waste of heat. Thus, while a decision as to the best source of heat for either of the first two classes is, as a rule, not difficult, more thought is required before making a decision in heat treatment problems.

There are, of course, intermediate zones in this classification in which local conditions may influence or fix the choice of the source of heat, and in many cases in these intermediate zones it may be difficult to accurately choose the best method of obtaining the supply of heat energy.

The importance of conducting heat treatment processes at definite and known temperatures has resulted in the development of pyrometry, the science of measuring temperatures above the range of the mercury thermometer. From the first use of the pyrometer as an indicating instrument have come instruments which, through their response to temperature changes within the heating chamber, provide for the control of the flow of heat to the chamber and thus make possible the control of the oven or furnace temperature within narrow limits.

Electric current has been termed the vehicle of heat energy, that is, the current conveys the energy along a definite and predetermined path to the point of application of the heat. Energy is useful only in the degree to which it can be controlled and electric energy has become the giant of industry through the precision and simplicity of its control. This ideal control is the same for the electric oven and furnace as for the other branches of energy utilization. The response of the pyrometer to even very small changes of temperature are exactly translated into the control of the current input to the electric heating chambers so that the flow of heat required to maintain a uniform temperature is a certainty, and this without skill or even thought on the part of the operator. This is an important consideration when the class of help required for the work is not of a high type.

APPLICATION OF RESISTOR TYPE OVENS AND FURNACES

With few exceptions, such as the heat treatment of some of the alloy steels, heat treatment processes are carried on at temperatures below 2,000 deg. F. and are thus within the range of the electric oven and furnace of the metallic resistor type. The resistors, in the form of bars of ribbon, can be distributed around the walls, roof and below the hearth of the heating chamber, thus distributing the flow of heat emitted from the resistor elements. Together with re-radiation from the walls, this makes possible an even distribution of temperature within the heating chamber so that all parts of the charge of material are evenly heated. With the electric oven or furnace, no intervening muffle between the source of heat and the work is

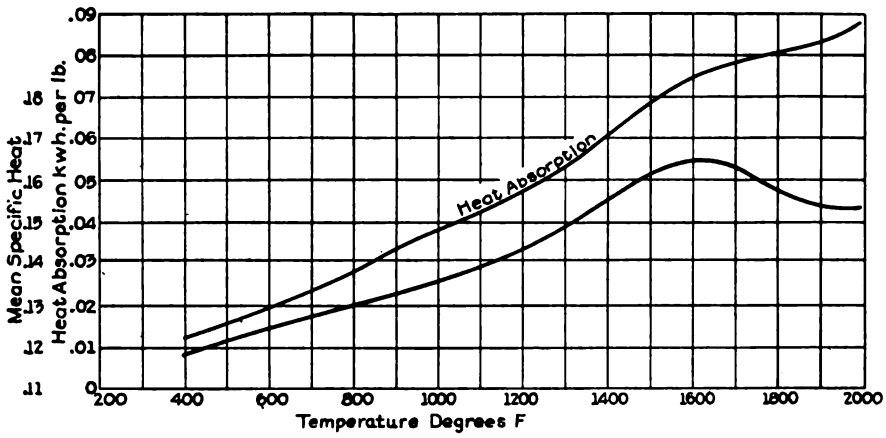


Fig. 3—These curves are used in determining the heat absorbed by a charge of carbon steel.

The lower curve gives the specific heats for temperatures ranging from 400 deg. to 2,000 deg. F. The upper curve gives the heat absorbed in kw.-hr. per lb. of steel for an initial temperature of 70 deg. F. and final temperatures as plotted on the horizontal scale.

needed to protect the material from excessive temperatures and from objectionable gases or to protect the resistors. Herein lies an important factor in the close control of temperature as the use of a muffle introduces a lag between temperature change and response in heat flow.

Control of Atmospheric Conditions in Electric Ovens

The operation of the electric heating apparatus is in itself independent of the atmosphere of the heating chamber, provided that there is no substance, such as sulphur, present in the atmosphere which would attack the alloy of which the resistors are composed. This, together with the fact that the heating chamber of the electric furnace can be made tight, provides for definite control of the oven or furnace atmosphere by the introduction of some inert gas (suited to the material and heat process) into the heating chamber.

The oxidization of the surface of metals in the presence of air is accelerated by heat and scale is formed in proportion to the amount of oxygen (air) available during the heat cycle. The amount of air in the heating chamber of the electric furnace is comparatively small and in many cases is not sufficient to be objectionable as regards scale formation. However, heat treatment is, in the majority of cases, applied well along towards the end of the manufacturing process, and for many tools, and also in the annealing of sheets and wire where the exposed surface is large and thickness small, even a small amount of scale formation is undesirable. The bright annealing of copper wire, through the use of an atmosphere of steam, is an example of atmosphere control. This process is illustrated in Fig. 4 on this page.

On the other hand, there are some heat treatment processes which require oxygen, for example baking varnishes, firing vitreous enamels, and similar applications.

For baking ovens some form of air circulation for the supply of oxygen and removal of vapors and smoke is usually necessary. For japan baking ovens forced ventilation is essential, as about two-thirds of the vapor formed from the naptha solvent is heavier than air and must be removed from the bottom of the oven. In Fig. 2 is shown an installation of japan baking ovens in which forced ventilation is incorporated. Where the size of the oven warrants the application, directed ventilation can be incorporated with some method of heat recovery from the hot gases so as to improve the overall economy of heat utilization.

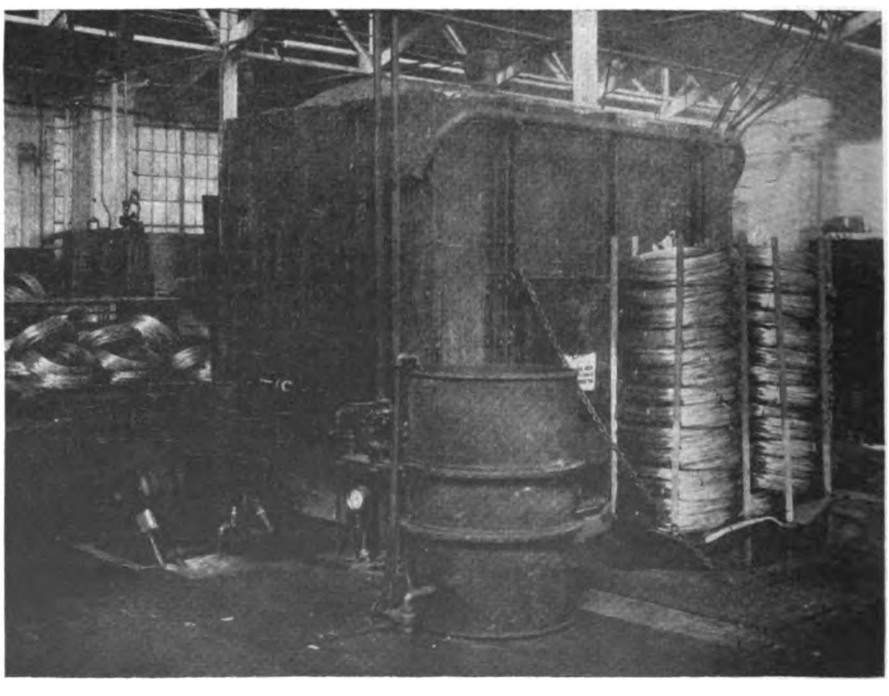
Effect of Electric Heat Load on Power Cost

The method of operation of heating equipment has much to do with economy in the use of heat. Power is purchased—or costs if generated within the industrial plant—on a sliding scale basis, this being accompanied by a maximum demand charge and a power factor charge; in some cases the rate structure is more elaborate than in others. The user of power is interested in the effect that the addition of an electric heating load will have upon the net rate per kw.-hr., as shown in the monthly bill. With the usual form of rate schedule, this depends upon how the heating load is super-imposed upon the light and power load of the plant.

Much of the possible utilization of current for heating is flexible as regards time, hence the placing of the heating load on the user's 24-hr. load chart with reference to the existing maximum demand for power, may be advantageous in that the increase in load does not increase the maximum demand. This, of course, is on the assumption that the demand of the heating load is less than the existing maximum demand, which may or may not be the case.

Fig. 4—This is a water sealed electric furnace for bright annealing of copper wire.

The furnace is rated at 300 kw., 550-volts, three-phase and takes a charge of 6,000 lb. The dimensions of the heating chamber are approximately 6 ft. by 4 ft. by 6 ft. high.



As the power factor of the resistor type heating load is unity this load adds only to the energy component of the plant load and the result is a betterment of the power factor of the electric load of the plant. Cases where the addition of an electric heating load have eliminated the power factor charge are not uncommon.

While the furnace or oven is at a temperature above that of the surrounding air there is a continuous loss of heat, the higher the temperature the greater the loss. Hence, the heating equipment should be kept in operation only while in use for heating material. Also, when the equipment is heated there is stored in the walls a certain amount of heat, which is a total loss when the heating chamber is cooled to room temperature. To minimize these losses, continuous use to maximum capacity, as nearly as may be possible, is desirable. Depending upon the character and flow of work, one or more small furnaces may be more economical than one large furnace.

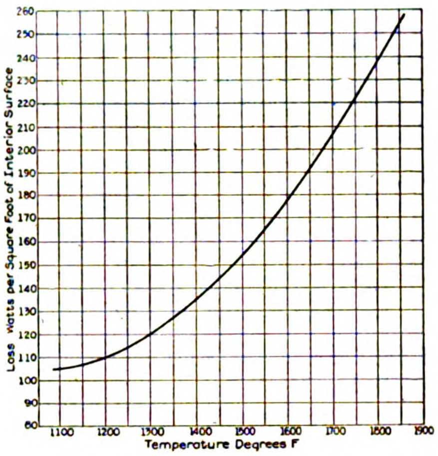


Fig. 5—This graph is used in determining the heat losses through furnace walls.

The curve gives the average losses for a temperature range of 1,100 deg. to 1,850 deg. F. for furnace walls having 4.5 in. of fire brick and 9 in. of heat insulation.

Factors Affecting Power Input to Oven or Furnace

As is typical of electrical apparatus generally, the cost of owning and using electrical heating equipment is comparatively easy to determine. The electrical input to an oven or furnace is the sum of the following items:

(a) Heat absorbed by the charges of material.

(b) Heat absorbed by the walls surrounding the heating chamber.

(c) The heat loss through the walls. (Dissipated at the outer wall surface while the oven or furnace is held at operating temperature.)

(d) For ventilated ovens, the heat absorbed by the air used for ventilation.

(e) The heat required for evaporation of moisture in baking and drying processes.

(f) In melting metals the heat required to supply the latent heat of fusion.

Let us consider each of these items in turn. Item (a) deals with the heat absorbed by the material placed in the heating chamber and is calculated from the following formula:

$P_m = (W \times s \times T') \div 3{,}413$ in which

P_m=kw.-hr.

W=weight of the material in pounds.

s=specific heat of the material.

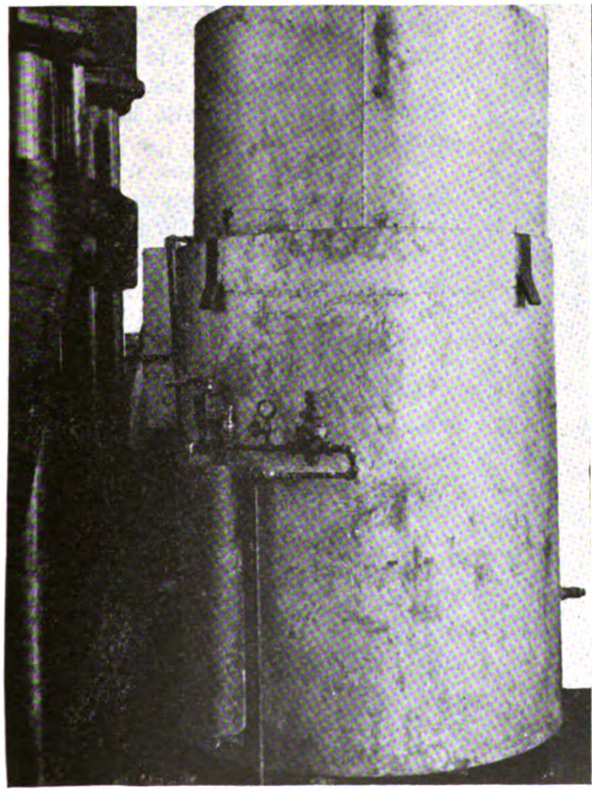
T'=temperature rise of the material.

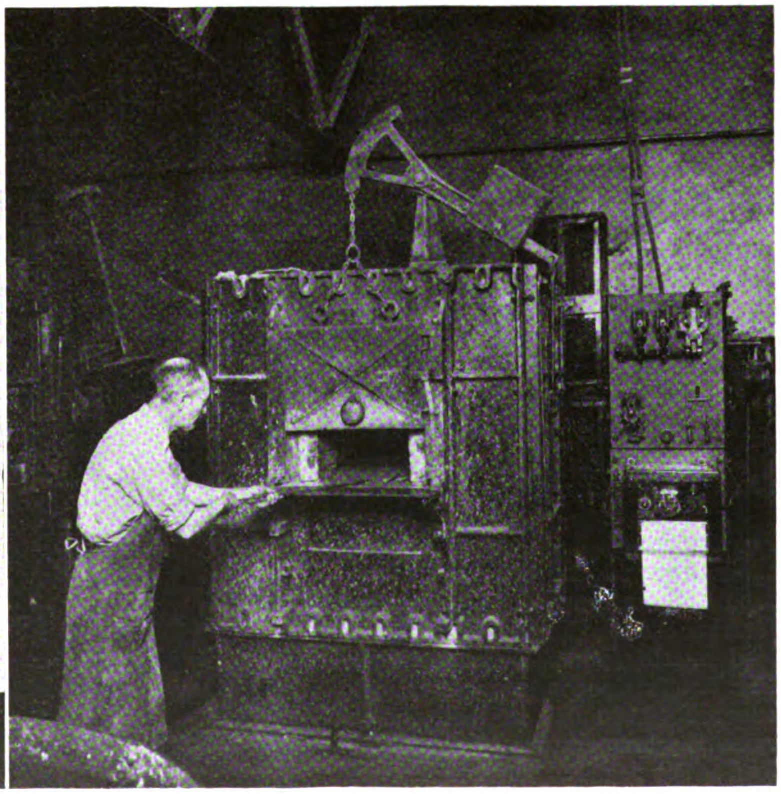
Included in the weight, W, should be the weight of the containers, if any, of the material, which, together with the charge of material, are removed from the furnace at the end of the heat cycle. As the specific heat of materials increases with an increase in temperature, the specific heat corresponding to the average temperature should be used. In Fig. 3 are shown the heat absorption and specific heats of carbon steel for various final temperatures and an initial temperature of 70 deg. F.

Item (b) concerning the heat

Figs. 6 and 7—At the left is shown an example of bulk heating done by electricity.

Fig. 6 shows an electrically-heated lead melting pot. Calculations of the heating requirements are given on page 158. In Fig. 7 is shown an early type of electric furnace (1919) that is still in use today. This is a box type, direct heat furnace used for hardening tool steel and carbonizing. The temperature range is 1,400 to 1,750 deg. F. The control and pyrometer are shown at the right.





stored in the walls is likewise obtained by the equation given in the foregoing. While this amount of heat is lost each time the equipment is cooled to room temperature, if the service is continuous over a considerable period of time the loss by wall absorption becomes a comparatively small item.

The chart shown in Fig. 5 gives average values for item (c) dealing with losses through the furnace walls of a type of construction which is economical for general use with medium and large sizes of electric furnaces. The materials of furnace walls and the thickness may vary both with the service and the size of the furnace. However, the average values given by this chart may be useful for estimating purposes. In Fig. 8 is given the power required to supply the wall losses of electric ovens.

For the ventilation of ovens (item (d) of tabulation on page 157), the heat energy required is given by the curves in Fig. 9 or may be calculated from the following formula:

$P_a = (V \times W \times s \times T^1) \div 3{,}412$

in which,

P_a=kw.-hr. per charge of material.

V=total volume of air in cubic feet required per charge of material.

W=weight of one cubic foot of air (At 50 deg. F., the weight equals 0.08 lb. approximately).

s=specific heat of air (0.23 approximately).

T^1=temperature rise of the air, deg. F.

A box type varnish baking oven usually requires 10 to 20 changes of air per hour. A core baking oven from 4 to 8 changes of air per hour. This in each case must be determined for the class of work that is to be handled.

For the evaporation of moisture (item (e) of the tabulation on page 157), the heat required is:

$P_v = (W \times 1{,}200) \div 3{,}412$

in which,

W=weight of water in pounds.

1,200=number of B.t.u. required to evaporate 1 lb. of water at atmospheric pressure.

As an example of the calculation for determining the heat required for melting metals (item (f) of the tabulation on page 157) let us determine the heat requirements for a lead melting pot such as shown in Fig. 6. This pot is required to melt one ton (2,000 lb.) of lead and to raise the temperature of the liquid lead to 660 deg. F. The temperature of the lead at the time of charging is 100 deg. F.

Latent Heat of Melting of Common Metals

Substance	B. T. U. per Lb.	Watt-Hours per Lb.
Aluminum....	180.00	52.80
Copper.......	78.00	23.00
Lead.........	9.65	2.82
Tin..........	25.60	7.50
Zinc.........	50.63	14.85

In the table on this page we find that the latent heat of fusion or the heat required to convert solid lead at melting temperature to liquid lead is 9.65 B.t.u. per lb. It is also necessary to know the melting point of lead together with the specific heats of solid lead and liquid lead. These data are listed in the following:

Melting point of lead....620 deg. F.
Specific heat of solid lead....0.0306
Specific heat of liquid lead...0.0402
Latent heat of fusion.....9.65 B.t.u

The heat required to convert the lead in accordance with our requirements will be composed of the heat required to raise temperature of lead to melting point, that is, 620 deg., the heat required to melt the lead, and the heat required to raise the temperature of the liquid lead to 660 deg. F.

The heat required to raise 1 lb. of lead to the melting point=(620—100)×0.0306=15.91 B.t.u.

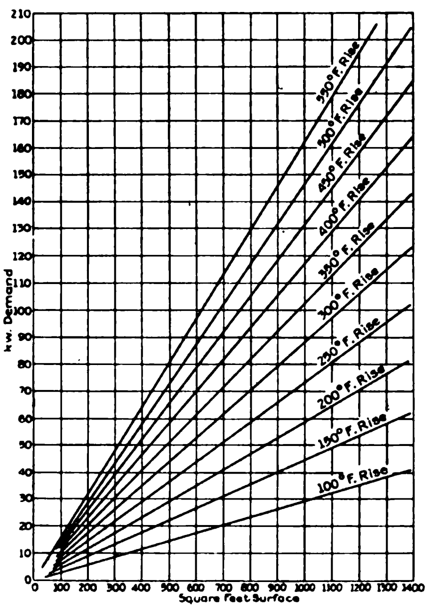


Fig. 8—This graph gives the average energy losses through oven walls.

The losses in kilowatts are plotted against square feet of oven wall surface and curves are drawn for various temperature rises.

The heat required to melt 1 lb of lead=9.65 B.t.u.

The heat required to raise the temperature of 1 lb. of the liquid lead to 660 deg. F.=(660—620)×0.0402=1.61 B.t.u.

The total heat required per pound of lead=15.91+9.65+1.61 = 27.17 B.t.u.

Heat per ton of lead=27.17×2,000=54,340 B.t.u.

Kw.-hr. per ton=54,340÷3,412=15.9 kw.-hr.

The actual kw.-hrs. per ton would depend upon the degree of heat insulation of the heating chamber and upon the method of operation. The electrically heated lead pot shown in Fig. 6 has a melting capacity of 3,500 lb. per hour. Under average conditions of one shift per day and including operation of the pot so as to hold the lead at working temperature overnight, the energy consumption is approximately 30 kw.-hr. per ton. For two shifts per day, approximately 25 kw.-hr. per ton is required. This is a use of electric current for bulk heating where the effectiveness and convenience of electric heat justifies its use.

Example of Heat Unit Costs of Electric Furnace

The open door loss of ovens or furnaces must be estimated from the size of the door opening, temperature of the heating chamber, and total time that the door is open during the heat cycle. For a preliminary estimate an addition of 25 to 50 per cent of the heat loss through the walls will usually be sufficient.

One example perhaps will suffice to illustrate the analysis of heat unit costs of electric furnaces. For this we assume a box type furnace for annealing steel, for which the following data are given:

Capacity, 800 lb. per hour.

Temperature, 1,500 deg. F.

Time of heat cycle, 45 min.—includes time for charging and discharging.

Furnace charge, 600 lb.

Size of heating chamber, length 82 in., width 45 in., height 33 in.

Assuming an initial temperature of about 70 deg. F., the heat absorbed by the steel per hour, from the equation given in third column of page 157 or from curve given in Fig. 3, is:

$P_m = [800 \times 0.16 \times (1{,}500 - 70)] \div 3{,}412 = 54$ kw.-hr.

The inside area of the heating chamber is 109 sq. ft. From Fig. 5, the constant loss through the walls while the temperature of the heating chamber is maintained at 1,500 deg. F. is found per sq. ft. of interior surface and multiplying this by 109 sq. ft. we obtain approximately 16 kw. The total power consumption is then 16+54=70 kw.-hr. per hr.

The maximum demand will depend upon the actual kw. in resistor capacity installed in the furnace. To shorten the time required for heating up from room temperature it is customary to make some addition, from 10 to 15 per cent, to the capacity required for the normal heating service. In this case, say 80 kw. would be the maximum demand.

To arrive at the total energy used over a period of time, it is necessary to base the estimate upon some definite method of operation and to take into account the loss of heat due to cooling during the hours the furnace is not in operation.

For the furnace which we have assumed, operating 48 hr. per week of 5½ days, the total weight of steel heated per week would be 38,400 lb. The corresponding total amount of heat absorbed by the steel is 2,575 kw.-hr. The average loss due to cooling must be estimated. In this case an average loss by cooling overnight of 10 kw.-hr. per hour, and over the week end 5.5 kw.-hr. per hour, would be reasonable values.

The heat loss for the week will be:

16 kw.×48 hr.=768
10 kw.×77 hr.=770
5.5 kw.×43 hr.=237

Total......1,775 kw.-hr.

The total power consumption per

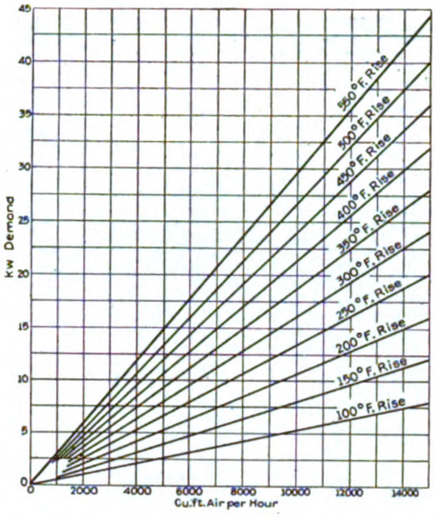


Fig. 9—Energy required for heating the ventilating air of ovens.

The volume of air to be heated is plotted against energy required to heat the air. Curves for various temperature rises are given.

week is then equal to 2,575+1,775=4,350 kw.-hr.

While for a given temperature rise, the heat absorbed by the charge of material is constant, regardless of the time of heating, the total heat required by the furnace depends upon the length of time of heating. This is of course obvious from the fact that the loss through the walls while the heating chamber is held at working temperature is constant. Hence, the shorter the heating period (which varies over a wide range for different classes of work), the less the power consumption per pound of material.

Cost of Heat Compared to Cost of Finished Product

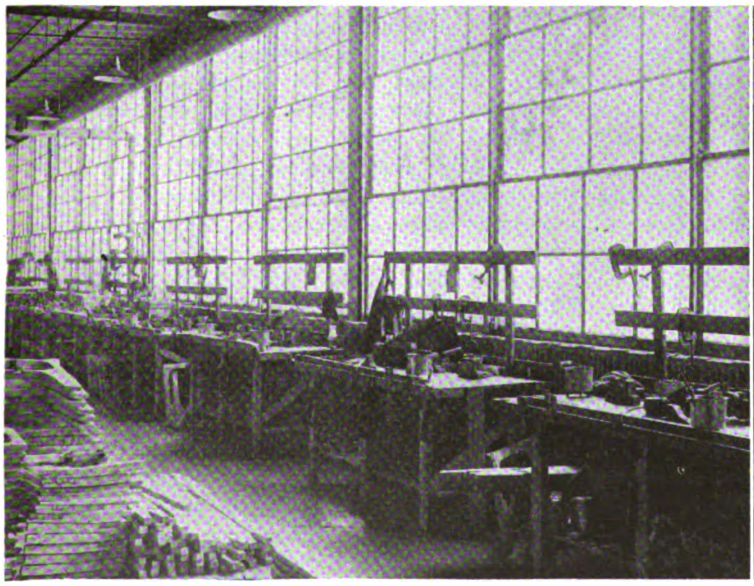
Perhaps there is nothing so well known among oven and furnace users today as that the cost of heat units required for heat treatment processes—whatever may be the source of heat—is but a small percentage of the total cost of the finished article. Hence, an analysis of the cost of owning and operating heating equipment should go beyond a comparison of heat unit costs and bring into the reckoning the many other items on which depend the cost of production.

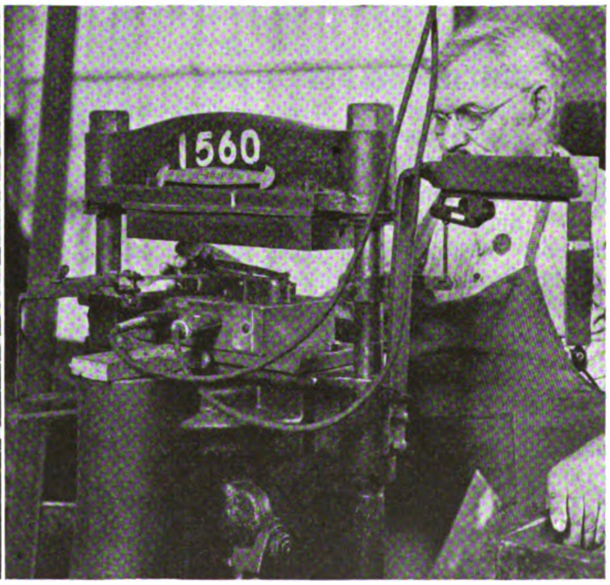
Included in the list of charges which go to make up the cost of the finished manufactured article are:

(a) The overhead cost.
(b) Maintenance.
(c) Labor cost.
(d) Cost of raw material.
(e) Cost of rejected parts.
(f) Rate of production.

High temperatures are the most prolific source of maintenance charges against heating equipment. It would be surmised that the maintenance cost of electric heating is low, because it is not necessary to create an excess of temperature in any part in order to obtain a desired temperature in the heating chamber, that is, the resistors operate at a temperature not far above that required for the heat process. At temperatures below 2,000 deg. F. the alloys used for the resistors have a long life. In furnaces the fire-brick

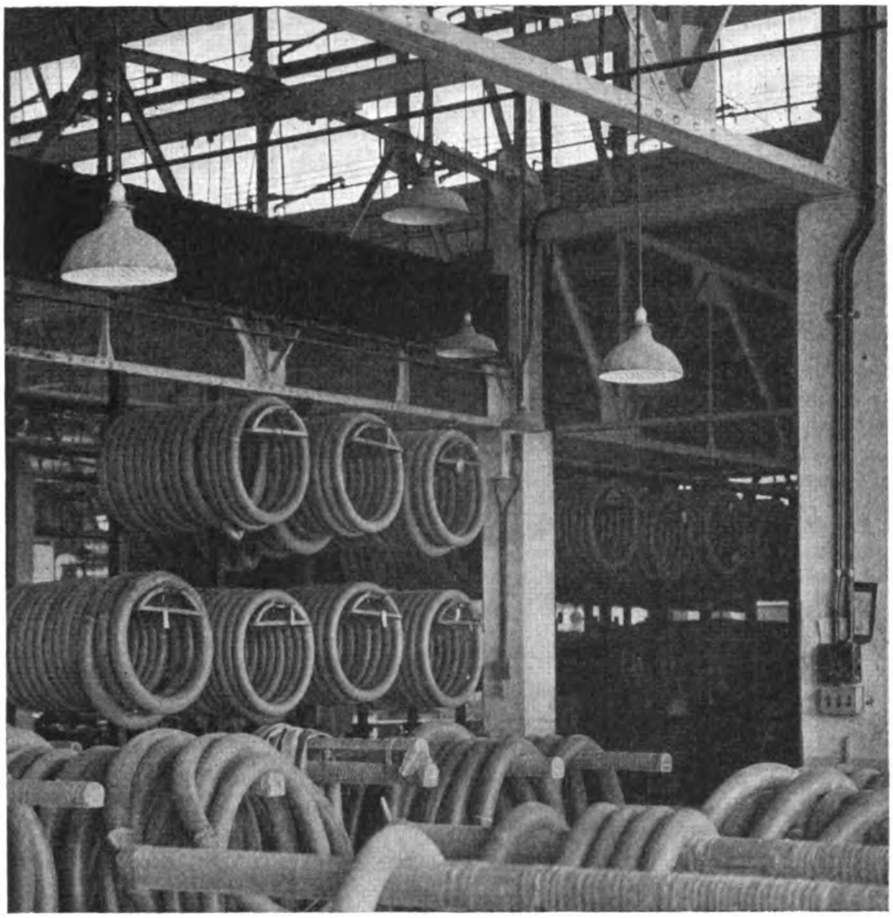
(Please turn to page 176)





Figs. 10 and 11—Two good examples of localized heating.

In Fig. 10 is shown an installation of two small cartridge units which are in a leather embossing machine at the Worcester (Mass.) plant of the Graton & Knight Mfg. Co. In Fig. 11 is shown an installation of 350, 1-qt., aluminum jacketless glue pots, in the woodworking department of the Willys-Overland Co., Toledo, Ohio.



Final inspection of inner tubes requires an intensity of 25 to 35 ft.-candles. This high level of illumination is obtained by suspending over each inspection rack, one No. 815 X-ray reflector and 200-watt lamp.

Considerations involved in

Planning Lighting System for a Tire Factory

with method of determining size and number of lamps necessary for illumination required, and factors that influenced layout of distribution system

By PHILIP CHAPIN JONES
Electrical Engineer, The Goodyear Tire and Rubber Company, Inc., Akron, Ohio

GENERAL principles underlying illuminating engineering apply, of course, to all installations. Nevertheless, their practical application to specific cases requires the exercise of good judgment in order to obtain the desired results. Some time ago the task of designing the lighting system for a large automobile tire factory devolved on me, and in this work some interesting problems were solved.

The system ultimately chosen resulted from a close study of the general arrangement of the factory, the illumination intensity required for the processes used, the spacing distances and mounting heights permissible, and so on.

In this instance, the processes which influenced the lighting were as follows: (1) Washing, wherein the crude rubber is fed between rolls to be washed and worked for the purpose of removing dirt and impurities. The nature of this work does not require a high intensity of illumination. (2) Milling, in which process the ingredients necessary to give the desired characteristics are worked into it. This operation requires higher intensity of illumination than does washing. Furthermore, the problem of obtaining proper lighting for this process is complicated by hoods over the machines. (3) Calendering, in which the rubber is rolled into sheets and gaged for thickness. Fairly high intensities are required for this work in order to detect imperfections. The work is in a vertical plane. (4) Tire building and finishing operations also require a rather high intensity of illumination. Moreover, it is necessary that the light come from low angles as the work must be closely inspected at all stages of the processes. The nature of the equipment and the conditions surrounding these processes are shown in the illustrations. The other processes involved in the manufacture of tires are not so exacting in their illumination requirements.

In all of these processes the work to be illuminated is black or very dark in color. For this reason higher intensities than usual are required, especially where the work must be inspected. For the dark fabrics dealt with in a tire factory the coefficient of reflection is 0.1, or less.

The lighting intensities required were determined by experiment, as we felt that this was the best way of solving the problem. Lamps of different sizes were tried in turn above the machines and the operators were asked to tell when, in their opinion, the illumination was sufficient for speedy, safe, and accurate work. Then the intensity of the light at the working plane was measured by means of a photometer which gave the illumination in foot-candles. If desired a foot-candle meter could be used for the same purpose. This instrument is not expensive, is easy to operate and gives direct readings in foot-candles. Another way of getting such information for general use is to secure it from various handbooks or from the Lighting Bureau of the National Electric Light Association, Nela Park, Cleveland, Ohio. This bureau has tabulated the intensities recognized as good practice in practically all of the leading industries. After the desired lighting intensity has been determined in any manner, good judgment must, of course, be used in changing the values as needed.

In this tire factory it was found,

as explained above, that if a general lighting scheme were used an average of 5.5 ft.-candles would be sufficient. Higher values might bring greater over-all economies and, in fact, in certain parts of the plant greater values are now in use. Again, the intensity of lighting necessary in certain places is considerably higher than it is in others. Thus, from 1 to 2 ft.-candles was found sufficient for storage, while from 20 to 40 ft.-candles are needed for inspection work. As it would be extravagant to maintain an average of 20 to 40 ft.-candles over the whole plant, local lighting was superimposed upon the general lighting in the few special places where these higher intensities were needed.

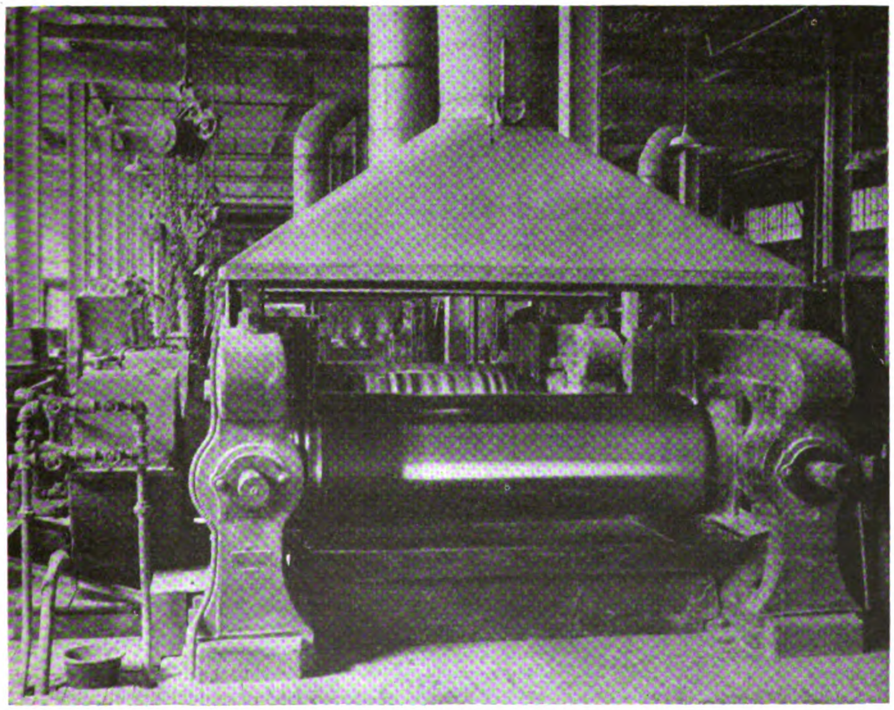
Assuming that the illumination required is 5.5 ft.-candles, the amount of light flowing to each square foot of working plane must equal 5.5 lumens. It would not be correct, however, to choose the size of lamps on this basis because some of their light is wasted in the reflectors and some is wasted by striking columns, machinery and other obstructions. With the R. L. M. standard dome reflector, which was chosen as the best for this installation, only 70 per cent of the light is usable, as 30 per cent is wasted in the reflecting surfaces, and otherwise. Therefore for this reason the amount of light flowing per square foot must be $5.5 \div 0.70 = 7.86$ lumens.

This does not take into account the light lost by striking machinery, columns and the like, which was figured in this case as amounting to 15 per cent, leaving available 85 per cent of the light. This 85 per cent is called the "Utilization Factor." This factor varies according to the color of the equipment and walls in the plant and the amount of obstruction in the form of pillars, belts and so on. With this utilization factor of 85 per cent, the total light sent out by the lamps must be further increased to $7.86 \div 0.85 = 9.24$ lumens per square foot. Having obtained this figure it was easy to calculate the watts per square foot as the average output value of type C gas-filled lamps is about 13 lumens per watt. Then the watts required equals $9.24 \div 13 = 0.711$ watts per square foot. Using this figure the size of lamps necessary was calculated as described later.

A system of general lighting rather than local lighting was adopted because the former was cheaper in this case and would light the plant quite as well if a few units for local lighting were also used. The cost of a lighting system consists of operating expenses and fixed charges; and fixed charges are proportional to the cost of installation. A brief study shows that the most costly items of a lighting system are the reflectors, lamps and switches. By reducing these to a minimum the lowest over-all cost may be obtained. Exclusive of the main supply lines, the cost of the general system decided upon was divided about as follows: Fixtures (including lamps), 61.8 per cent; switch wiring, 25.1 per cent; and main wiring 13.1 per cent.

Milling the rubber requires a fairly high intensity of illumination.

In this operation, coloring matter and other ingredients are thoroughly mixed into the rubber by passing it through these rolls. Light is thrown directly on the rolls by a 50-watt lamp suspended from a drop cord which passes through the hood. A socket and plug are used just above the hood to allow removal of the latter for repairs. Armored conductor is used in passing through the hood. Type PWP cord is employed between the ceiling and the socket, to take up vibration.



As a good rule to follow it may be stated that where a few operations or machines are used over a large area, local lighting is cheaper as there is but one reflector, lamp and switch for each machine, and very few of these per 1,000 sq. ft. Where a large number of machines or operations are crowded into comparatively small areas, general lighting is cheaper, as fewer reflectors, lamps, and switches are required.

The operating costs are determined by the number of reflectors, lamps and switches installed. Reflectors must be cleaned, lamps renewed, and switches repaired. There is, however, one other factor that often assumes large proportions; namely, changes in location of equipment. If equipment is being moved about frequently the cost of moving the local lighting units becomes a large part of the operating cost. With general lighting, where the lamp locations are independent of the machinery locations, this factor does not enter. The tire industry is comparatively new and its processes are constantly being changed or improved. Expansion is also rapid and the demand changes from one set of sizes to another, or from one type of tire to another. All of these changes demand new layouts and the expense of changing local lighting systems would probably exceed all other items of operating cost. As the lighting distribution factor of a tire plant is high, the choice of general lighting becomes obvious.

With a building construction having definite bays separated from each other by columns and deep beams, it is necessary to take the bay as a unit of area in designing the lighting system. The lamps must be more or less symmetrically placed in each bay and all bays must be alike. As the bays in this factory are 20 ft. by 20 ft. they require a total of 284 watts each, on the basis of 0.711 watts per sq. ft., which was the figure found necessary to give

5.5 ft.-candles. Using standard size lamps would round this off into 300 watts per bay, giving slightly more than 5.5 ft.-candles average intensity. This wattage might be supplied in either two 150-watt lamps, three 100-watt lamps, four 75-watt lamps, or six 50-watt lamps. The determining factor is the distribution, as the fewer lamps used the less would be the cost of the system.

The relation between minimum and maximum intensity in a bay should be as near unity as is possible with reasonable economy. To determine this point the test shown in the accompanying table was made of the relation between the number of lamps and the ratio of the various intensities resulting. This test was made under the conditions that there were no obstructions to cast shadows, the bays were 20 ft. by 20 ft., the mounting height was 9 ft. above the working plane, and the reflectors were R. L. M. standard dome. Four bays, a section 80 ft. by 80 ft. square, were lighted while the test was made so that light from the four bays came to every point.

It was apparent from this test that it would be unnecessary to use more than three lamps per bay, as a ratio of 0.950 was obtained with three lamps. If the conditions assumed in computing these figures—no shadows and large spaces—could always be realized, two lamps per bay would be adequate, as with these the ratio would be 0.788. However, in practice this is not possible; so three units per bay were chosen. Moreover, the choice of three units per bay was desirable in this case for another reason. With the units selected, each has a 100-watt lamp. If it is so desired in the future the intensity may be increased 50 per cent without changing the reflectors, as a 150-watt lamp will fit the same equipment. In parts of the plant this has already been done.

In order to have the fixtures above the bottom of the I-beams, thus affording protection, and at the same time giving a more even distribution of light, a mounting height of 11 ft. 6 in. above the floor was selected.

For construction reasons and because any partitions erected will ordinarily follow bay boundaries, the control of the lamps should ordinarily be divided according to bays with one, two or three bays per switch. If all the lamps were lighted at once the cheapest arrangement, from the standpoint of installation, would be to control three bays by each switch. Much of the time, however, only small sections of the lighting system are in use. By the use of fewer switches a saving would be made in first cost, but this would be at the expense of an increase in operating cost, caused by lamps being burned unnecessarily. This problem is not subject to precise solution and, as the best compromise, the practice of controlling two bays per switch was chosen. A typical section of the factory is shown in one of the illustrations. The lamps are arranged three in each bay, symmetrically with respect to the bay and in orderly rows across the entire plant.

After these details had been settled the distribution system had to be designed, keeping these factors in mind: An adequate supply of power for lighting under unexpected conditions must be assured; changes must be easy of accomplishment; the construction must be rugged, and at the same time economical. Efficiency in the use of materials and labor must be the keynote.

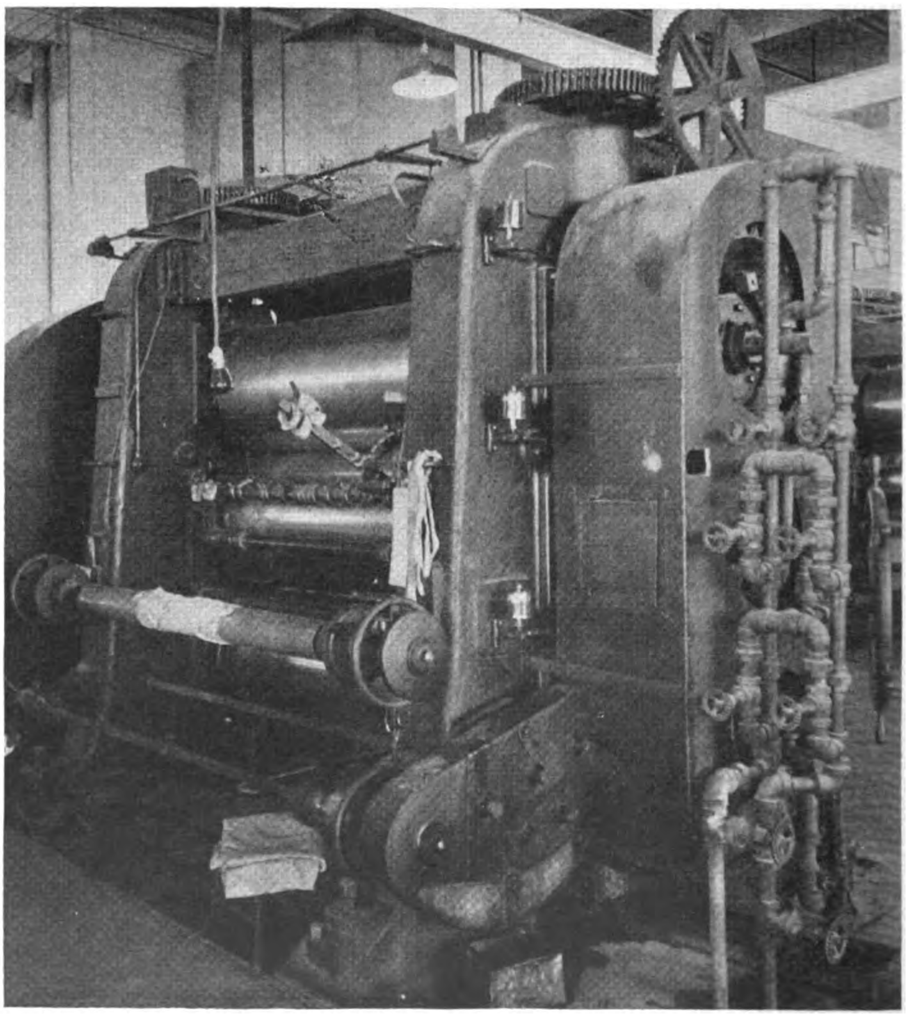
The average connected load is 0.75 watts per sq. ft. (three 100-watt lamps in a 20-ft. square bay) or a total of about 365 kw. for the building, including basement. However, as lighting intensities are increasing it seemed wise to allow a capacity of at least 1 watt per sq. ft., as a basis of feeder capacity, thus giving a total connected load of approximately 550 kw.

The primary voltage is fixed generally by considerations other than lighting distribution. In this case, energy is obtained from the power house about 1,000 ft. distant. Obviously, it would not be wise to transmit at the lamp voltage currents of several thousand amperes. However, 2,300-volt, three-phase energy was available and as this was being used for all power distribution it was the natural choice for the lighting distribution as well.

For the lamp voltage there can scarcely be said to be any choice at

Calendering also requires a high level of illumination.

The rubber is rolled into sheets of definite thickness on these rolls and must at the same time be inspected for imperfections. As the general illumination of approximately 5.5 ft.-candles is not sufficient for this work, it is supplemented by the use of a 50-watt lamp in a half-reflector guard, which throws light onto the rolls.



all. While 220 volts are still used to some extent the lamps at that voltage are more expensive, less efficient, and more fragile. In the vibration existing in most plants their life is very short. They are also at a disadvantage from a safety standpoint, particularly where extensions are used. Thus 110 and 120 volts are being used more and more, and a great many 115-volt lamps are in use. This is a very good value, linking in with the 230-volt and 2,300-volt series which are now more common than the older 110, 220 and 2,200 volts. We decided to use 115 volts.

Although the choice of 115 volts for the secondary system is simple, the choice of the type of secondary distribution is not so obvious. There are three possibilities which, with their corresponding percentage currents for any given load, are shown below:

Volts	Type	Per Cent Current
115	1 phase	100
115	3 phase	57.7
230/115	3 wire	50.0

In deciding between these three possibilities there are several factors to be considered. The basis of comparison is the relative economy of operation of the three systems when designed for equal line drops. Under this condition the controlling factors are total copper required and line losses (I^2r).

Omitting the very simple calculations required, we obtain these results.

System	Number of Wires	Copper Required Per Cent	Losses Per Cent
115 volts, 1 ph.	2	100.0	100.0
115 volts, 3 ph.	3	75.0	100.0
230/115 volts, all conductors same size	3	75.0	50.0
230/115 volts neutral one-half size	3	62.5	50.0

Omitting Case 3, which for an ordinary lighting system would be indefensible, the three-wire system seems at first sight to offer some economies, although the figures given are for cost of copper only. The complete cost of installation, including cost of all material and labor, would not stand in a similar ratio.

The three-wire system has, however, certain objectionable features which may offset its advantages. First, bringing 230 volts, instead of 115 volts, into the lighting cabinet entails increased danger to employees, with greater liability of short-circuits, and likelihood of greater damage by them when they occur. With the three-wire system there is also the possibility of bringing 230 volts directly into the sockets by careless wiring, which unfortunately we always have to consider.

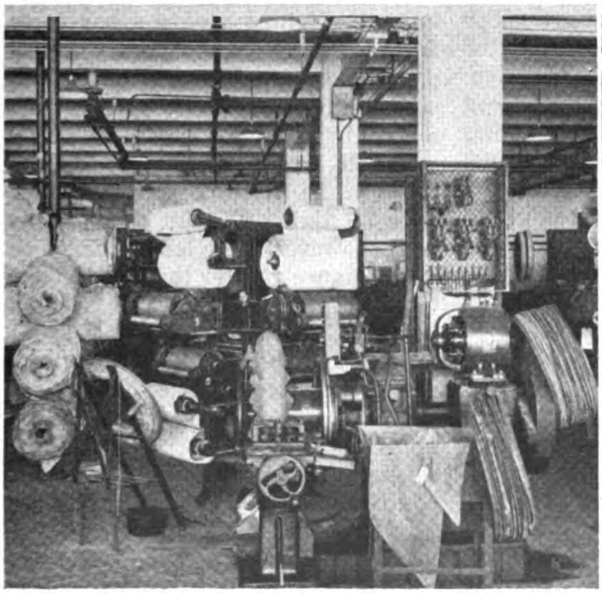
Aside from these disadvantages, which are potential rather than actual, there are one or two relating to transformer grouping. With a three-wire system each bank takes energy from a single phase only, so that where the supply is three phase there is usually an unbalanced circuit. The primary wiring arrangement is also not so convenient, for cable is generally used and it is necessary to make an awkward, single-phase termination for a three-phase cable or to use both three-conductor and two-conductor cable which, of course, increases the stock of spare cable to be carried. Furthermore, where a bank consists of one or at the most two transformers, any transformer trouble will cause a loss of lighting until the defective transformer is replaced. With a three-phase system using three transformers per bank in closed delta, if there is trouble on one transformer it can be cut out and a good portion of the load carried on the other two in open delta until the third transformer is replaced.

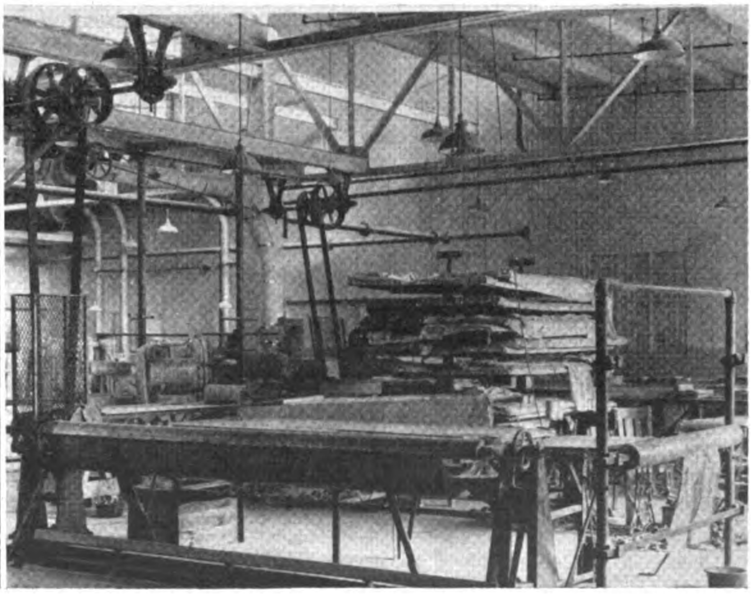
Where smaller total capacity is desired, open-delta banks or single-phase banks may be used with a slight decrease in reliability. In the plant under discussion the decision was made in favor of the three-phase system. It was felt that the many

How Distribution of Light Is Affected by Changing Number of Lamps in a Bay

Lamps Per Bay	Minimum Intensity Ft.-Candles	Maximum Intensity Ft.-Candles	Ratio of Max. to Min. Intensity	Average Intensity Ft.-Candles
1	5.28	10.05	0.528	7.66
2	6.00	7.61	0.788	6.80
3	6.69	7.05	0.950	6.87
4	6.51	6.89	0.945	6.70

These tests were made under the following conditions: Bays 20 ft. by 20 ft., lamps mounted 9 ft. above working plane, in R. L. M. dome reflectors, and arranged symmetrically, with no obstructions to cast shadows.





General illumination of 5.5 ft.-candles is not sufficient for tire building, left, and tube wrapping, right.

Both of these operations also require that the light come from low angles, to facilitate close inspection. Over the tube-wrapping table two No. 815 X-ray reflectors with 200-watt lamps give an intensity of nearly 30 ft.-candles. This high level is necessary to avoid wrinkles in the wet, black fabric that is wrapped around inner tubes preparatory to curing them.

advantages overweighed the difference in cost.

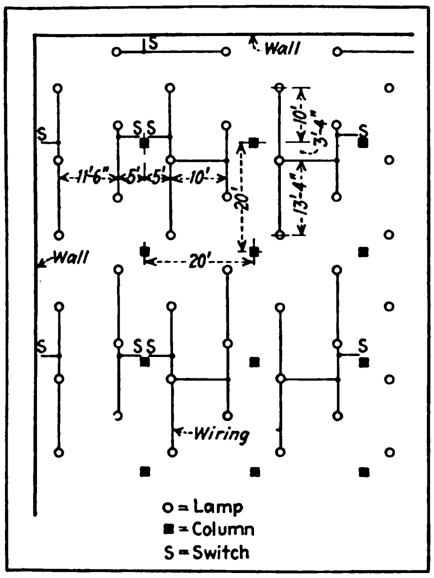
The size of transformer was set at 25 kva. in all cases for the regular lighting. The criterion for size is mainly the average size of the buildings to be lighted. The upper limit would be set by the amount of space that can be economically fed at 115 volts. Where the voltage drop is to be kept around 2 per cent, the maximum distance for the most economical transmission at 115 volts is from 50 to 150 ft., depending on the type of construction. Thus, where three- or four-story buildings are used and fairly high intensities arranged for, this limit is rather high. With transformers placed at the center of the long side of a rectangle, spaces 200 ft. by 100 ft. can readily be handled.

The structure of the 115-volt distributing system is always a subject of study and often one of special difficulty. The alliterative trinity of cost, convenience, and Codes is inextricably jumbled. There are two general schemes: central and distributed control. The first system has a main cabinet from which all the lights are controlled; in the second system the lamps are controlled locally by conveniently-placed switches. Both systems have their various modifications.

The advantage of the central control system is that all lighting is brought under the supervision of one person, which is very desirable under some conditions. It has, however, many disadvantages. With this system the leads from the transformers are run to a cabinet where each circuit is tapped onto a main bus through cutouts. The individual circuits may run to their respective distribution areas in any manner desired, conduit or open. The only reduction in wire size is in the main cabinet, where there are fuses to satisfy the Underwriters' requirements. Thus, we have of necessity longer runs of small wire and must use more copper to hold up the voltage. In general, the central control system is more expensive than the dispersed control system and can be justified only by the necessity of having the lighting under unified control or by Code requirements.

The advantages of the dispersed control system are lower cost of installation and the control of the lights by the workers themselves to suit their local needs. The difficulty with the dispersed control is in obtaining the proper reduction in wire size in an economical and practical manner without Code infringement.

In our case a main cabinet was placed just inside the wall from the transformers, which in all cases are hung on the outer walls of the buildings on steel platforms. In this cabinet is a fused main switch feeding a short copper bus and No. 4/0 risers which go up and down to other floors. These risers are fused, which gives the first of a series of four reductions before the ultimate No. 14 conductor is reached. On each floor is a cabinet fed by the No. 4/0 riser, having two branch circuits of No. 2 conductor with fused switches. These No. 2 conductors are floor mains and run down the center of the building, one in each direction. Tapped onto these, through fused switches, are No. 8 mains running across the building. The individual lighting circuits are tapped to these No. 8 cross mains. Both the No. 8 and No. 2 mains are of triple-braid, slow-burning wire stretched open and suspended from the bottoms of the floor beams above.



The lamps in two bays are controlled by one switch.

Study of all of the factors involved showed that the arrangement of switches and wiring shown here was the most economical. In this installation six lamps are controlled by one switch, except at the corners and near the walls, where the lamps are controlled in groups of two or three.

One of the points of greatest conflict between cost, convenience and Codes in the open main system of lighting distribution is the run connecting the main with the circuit cutout.

Under ordinary operating conditions this section of wire between the fuse and the mains is protected by the branch fuse. The only situation under which protection is not afforded is when trouble occurs on this section itself. Owing to the shortness of the run and the fact that it is all in conduit, however, the chances of trouble here seem very remote. The only thing to be really feared is that in case of short-circuit on this section the wires in the drop might fuse and cause fire or other injury before the fuses in the mains would blow. In coming to a decision in the matter it was, therefore, finally agreed that the wire between the main and the fuse need be only large enough not to fuse at a current which would blow the fuses in the mains.

From the fuse on to the lights, excepting 10 ft. of conduit up the column, all the wire is No. 14 r.c. run open on cleats fastened to the ceiling. The 24-in. I-beam between the two bays on each circuit was passed by means of a short piece of conduit bent over the top of it and embedded in the floor above. Where the floor is concrete 4-in. by 4-in. wooden inserts were placed in it at every cleat position.

The voltage regulation is very close. The 2,300-volt lighting feeders are fed from a lighting bus through an induction regulator compounded for about 2 per cent line drop. Under the worst normal conditions the voltage at the lamps does not vary 2 per cent from the rated voltage.

Tests were made on the completed system with a Leeds & Northrup photometer. A bay was marked off into 2-ft. squares and readings were taken at the corners of each square. An interesting fact discovered was that only 51 per cent of the total light flux falling within a bay came from the lamps in that bay, while 49 per cent came from the lamps in surrounding bays. This was determined by taking a reading, first, with all lamps turned off except those in the bay concerned, and then with all lights on. In none of the tests, however, were lamps turned on at a distance greater than 40 ft. from the bay under test. The average illumination was found to be 5.05 ft.-candles and the ratio of minimum to maximum intensity was 0.78. This ratio figure shows the effect of columns and other obstructions. This scheme of general lighting with the addition of local lighting for inspection and other special work, has been used now for some time with very satisfactory results.

PRACTICAL operating data on leather belt drives, particularly information regarding their power-transmitting capacity under various service conditions which has been obtained from a series of extensive tests carried on at Cornell University by The Leather Beltintg Exchange Foundation, are contained in this article.

Tests which show

Capacity of Belts Under Operating Conditions

with particular reference to the relative power transmitting capacity of leather belts on vertical and angular drives

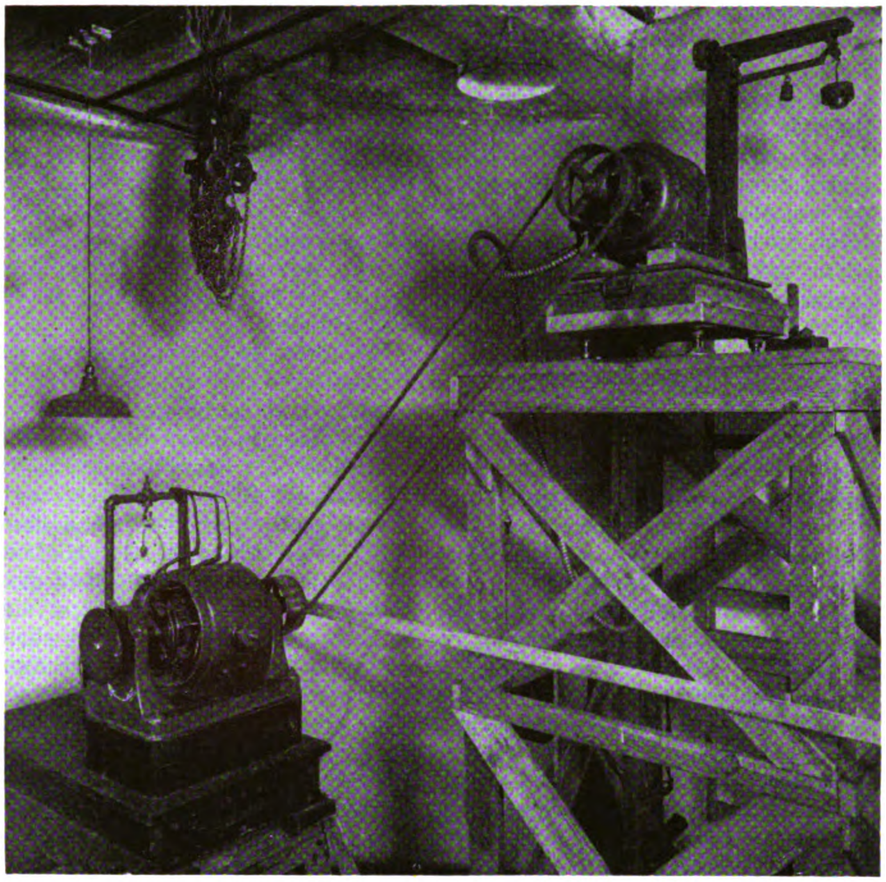


Fig. 1—Angular drives were tested by raising the dynamometer and moving it to the side.

By R. F. JONES

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BELT drives, although by far the most common method of connecting two shafts or machines or the drive to its machine, are altogether too frequently laid out by rule of thumb or by guess. To provide reliable information, which could be used by practical operating men, on the power transmitting capacity of leather belts, The Leather Belting Exchange Foundation, has conducted a series of extensive tests on belts operating under various service conditions. The results obtained by some of these tests were given in an article* entitled "How Service Conditions Affect Belt Capacity," which appeared in the June, 1925, issue of INDUSTRIAL ENGINEER.

This previous article gave easily usable information that would assist operating men in laying out a belt drive and enable them to make the proper allowances for some of the conditions which affect its power transmitting capacity. Conditions tested and reported at that time covered the effect of diameter and ratio of pulleys, center distance, and high belt speed on horizontal belt drives, and also the use of the gravity belt idler. A large number of tests were made under a variety of operating conditions.

The results obtained from these tests were given in the form of curves and tables that indicated the power which various weights of belts are able to transmit at different speeds, and the correction factors which indicate the necessary allowances to be made for the types of drive indicated according to pulley size and distance between centers.

Since that time additional tests have been made to compare the power transmitting characteristics of belts operating horizontally, vertically, and at various angles with the horizontal. This information is incorporated in the present article to serve as a guide in the layout and design of these drives. In addition, the author has correlated the results with the method of belt drive design published previously so that this same system with the indicated modifications can now be used for vertical and angular drives.

Our regular 100-hp. laboratory apparatus, which was illustrated in the previous article, could not be used for this work without prohibitive trouble and expense; so parts of a smaller machine often used for demonstration work were employed. The principal units of apparatus used were, a 15-hp. electric cradle dynamometer, two 10-hp. electric motors, and a platform scale. This type of dynamometer is in such common use for absorbing and measuring power that a description of its construction and operation is unnecessary here.

One of the motors was mounted overhead on the platform scale, which was supported by an elevated platform about 8 ft. high, as shown in Fig. 2. Placing the motor on the scale provided a reliable means of measuring the belt tension, since any load registered by the scale beyond the tare weight of the motor and auxiliary apparatus was due to belt tension. Four especially designed jackscrews which allowed about 6 in. of vertical movement to provide for adjusting the belt tension supported the scale and motor. These jacks are operated from below by handwheels which cannot be seen in the picture.

In Fig. 2, the belt is driving vertically from the overhead motor to the dynamometer. The other motor,

*Readers who do not have copies of the June, 1925, issue of INDUSTRIAL ENGINEER on file may obtain the information on which this previous article by Mr. Jones was based by requesting Report R-13 from The Leather Belting Exchange, 417 Forrest Building, Philadelphia, Pa.

shown on the left, was used to drive the dynamometer through a horizontal belt, at the same center distance and belt speed. In this way the belt could be changed from one drive to the other in a few minutes, and thus enable us to obtain a comparison of the two drives under the same conditions.

On the horizontal drive the belt tension was applied by weights which pulled on a cable attached to the motor. This cannot be seen in Fig. 2, but a track and two of the roller-bearing wheels will be noticed supporting the motor. Great care was taken to level the motor track so that the unweighted pan and cable would just balance the frictional forces on the wheels, thus insuring that no tension would be added to nor subtracted from the desired belt tension by gravity or friction.

This apparatus adapted itself very readily to tests at other angles than the vertical, because the dynamometer could be raised and moved to the left to give the required angle and center distance, as illustrated in Fig. 1. Tests were made in this way on belts operating at 45 deg. and 67½ deg. with the horizontal. The scale measured only the vertical component of the tension, and consequently the correct tension on the angular belts was obtained by using a scale setting equal to the sin of the angle times the desired belt tension.

Cast-iron pulleys 10 in. in diameter and with 4-in. faces, which had been well polished by usage, were employed. Both motors had a no-load speed of 1,200 r.p.m., and a full-load speed of 1,160 r.p.m., which gave a belt speed of between 3,100 and 3,200 f.p.m., depending on the load and slip.

Accurate slip measurement was accomplished through the use of our rotating-lamp slipmeter, which will be explained in detail for the benefit of those not familiar with the apparatus. Where the driver and driven pulleys are the same diameter, as in this case, a small brass plate is mounted on the fiber drum called the contactor, and this is attached to the motor shaft, as shown in Fig. 3. At one end of the dynamometer shaft is a black disk or dial upon which is fastened a flashlight bulb. Current is supplied to the bulb through slip rings and brushes as indicated, and the light will flash every time the contactor plate comes around to its brushes.

When the belt is running at no slip the two shafts will revolve at the same speed, and the light will always appear at the same point *0*. If belt slip is present, the dynamometer shaft will not revolve as fast as the motor shaft, so that when the motor shaft has made a complete revolution, the driven shaft has only reached position *1*, where the light flashes. The next revolution of the motor finds the light at position *2*. The distance from *0* to *1* and from *1* to *2* is the slip during each revolution. These distances are, of course, exaggerated in Fig. 3 to emphasize the principle of the slipmeter.

In use, the machines are running so fast that the light appears as a streak, which moves whenever slippage occurs. Every revolution of the light indicates the loss of a revolution through slip. Dividing the r.p.m. of the light by the r.p.m. of the driver and multiplying by 100 gives the percentage of slip.

Procedure Followed in Making Belt Drive Tests

Two different high-grade leather belts were used in these tests as a check on the accuracy. In addition, similar tests were also made on belts of other materials, but the results and curves obtained are not included in this article. A few tests were made on the flesh sides of the leather belts for comparison between the vertical and horizontal drives. The dimensions of the two belts are approximately as follows: Belt No. 1 was 1 in. wide, 0.204 in. thick and

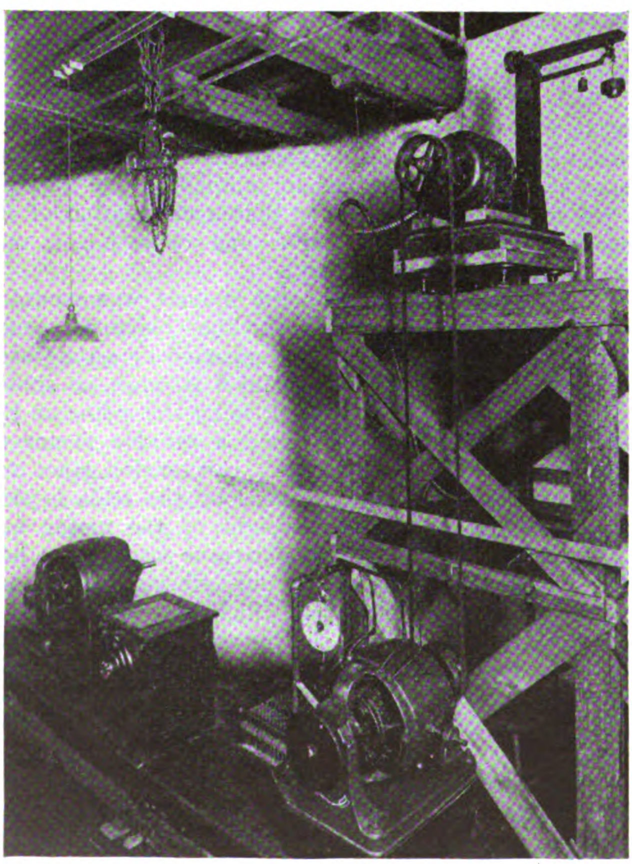
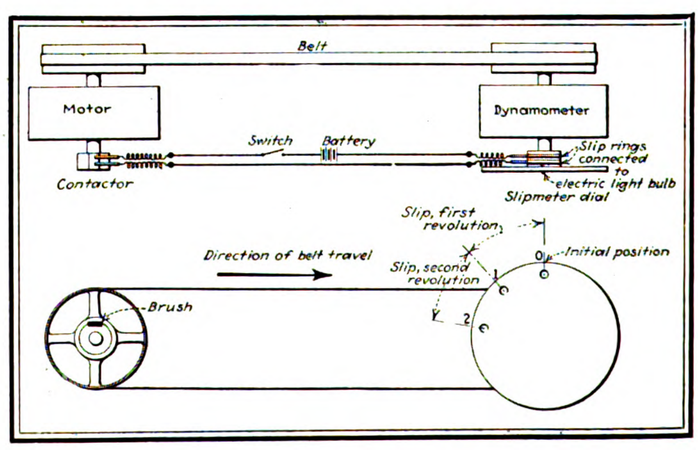


Fig. 2—Tests were first made on horizontal and vertical belts with the apparatus set up as shown.
The dynamometer is located in the lower foreground and can be connected by the same belt either to the motor on the scales on the platform to operate as a vertical drive or transferred quickly to the motor at the left to operate as a horizontal drive. The apparatus is so designed that all conditions can be kept constant, and as the change can be made in a few minutes the results are comparable.

Fig. 3—Slip is measured by this rotating-lamp slipmeter when the pulleys are of the same diameter.
A flashlight bulb is mounted on the black dial and connected through brushes and a special commutator on the motor shaft to light at each revolution. If there is no slip the light will remain at the initial position *0*. Due to the slip the light travels to position *1*, then to *2*, and on around: each revolution of the light indicates the loss of a revolution through slip.



weighed 15.2 oz. per sq. ft.; belt No. 2 was 0.965 in. wide, 0.19 in. thick and weighed 14.85 oz. per sq. ft.

These belts had been used previously for other work and therefore were well run in. It is necessary before any tests are made that each belt be run long enough to be sure that its surface condition is constant, or nearly so.

The belt tension was set when the test belt was running at normal speed under no load. We have designated this as "the light-running tension" (*LRT*) to differentiate it from the "initial tension" which is set with the belt at rest, or "the slow-running tension" which is set while the belt is running very slowly.

Three light-running tensions were used in most of the tests: namely, 50, 75, and 100 lb., which range was great enough to show the effect of tension under the various conditions. The tension in each individual strand was one-half of the light-running tension.

The tests were divided into two groups: First, a series on belt No. 1, which were made primarily to compare the power transmitting characteristics of the horizontal and vertical drive; second, tests on belts Nos. 1 and 2 which were made to compare the 45-deg. and 67½-deg. drives with the horizontal and vertical drives. A *test* consisted principally of slip readings taken as the load was increased in increments until the maximum capacity of the belt had been reached. Care was taken to maintain the room temperature practically constant, and the relative humidity was measured at frequent intervals.

With the first group of tests, which compared the horizontal and vertical drives, we made tests on one of the two drives at the three light-running tensions, and then immediately changed the belt to the other drive and repeated the three tests. This method eliminated the possibility of error due to surface or humidity changes. Five series of comparative tests were made in this way. All horizontal belt tests were made with the tight side on the bottom and all comparisons of the different drives will be made on a tight-side-below basis.

The second group of tests, which investigated angular drives, had to be handled in a little different way. Here the apparatus was first set up to run the belt at 45 deg. and tests were made on belt No. 1 at each of the three tensions with the tight side of the belt on top and then on the bottom. Tests comparing the tight side above and below were made directly following one another. Then the dynamometer was moved to give a 67½-deg. drive and the tests were repeated. Following these, vertical and horizontal drive tests were made to get a basis for comparison of results under practically the same operating conditions.

Table II—Effect of Center Distance on Horizontal Drives

Center Distance in Feet	Per Cent Difference
5	6
10	15
15	19
20	21
25	23

Per cent difference= $[(H\text{-}V) \div H] \times 100$.

Careful analysis of the data obtained on the first tests revealed inconsistencies which could not be entirely explained; so more tests were made on belt No. 2, in the same way as before except that the tight-side-above tests on the angular drives were omitted. A few additional tests, made principally to check the accuracy of the apparatus, completed the work.

Preliminary Discussion of Results Obtained

A total of 88 tests were made during the progress of the investigation. As it is impracticable in this report to show curves for all of these tests a few representative curves have been selected as illustrative of the results obtained. Figs. 4 and 5 show the transmission characteristics of a leather belt (grain side) and a leather belt (flesh side) on the horizontal and vertical drives. Figs. 6 and 7 are given as typical curves of a leather belt (grain side) running at 67½ deg. and 45 deg. with the horizontal. These will be discussed in detail later. The following nomenclature has been employed in marking the curves:

67½ deg.=Belt running at an angle of 67½ deg. with horizontal.
H=Belt running horizontally.
V=Belt running vertically.
45 deg.=Belt running at an angle of 45 deg. with horizontal.
T_1-*A*=Tight side of belt on top.
T_1-*B*=Tight side of belt below.

Unless a curve is marked T_1-*A*, it is understood that the tight side of the belt was on the bottom. Each curve is labeled with the *LRT* (light-running tension). On all curves, the horizontal axis indicates the percentage of slip, and the vertical axis the horsepower transmitted.

Considering first the horizontal and vertical drive comparisons as shown in Figs. 4 and 5, the horizontal drive (using T_1—the tight side below) transmitted more power than the vertical drive in every case, the difference depending on the side of the belt used and the tension. The superiority of the horizontal drive becomes less pronounced as the tension is increased.

There is not much difference in capacity at slips below 2 per cent with a high-capacity leather belt such as No. 2, Fig. 4, because most of the slip up to this point consists of creep, which is due to elasticity and is practically the same on either

Table I—Comparison of Tests on Horizontal and Vertical Belt Drives

			Per Cent Slip								
			1.5			2			3		
Belt	Surface Against Pulley	LRT	Hp. Hor.	Hp. Vert.	Per Cent Diff.	Hp. Hor.	Hp. Vert.	Per Cent Diff.	Hp. Hor.	Hp. Vert.	Per Cent Diff.
No. 1	Grain	50	5.55	5.10	8.10	6.85	5.6	18.2	7.6	6.0	21.0
No. 1	Grain		5.2	5.0	3.8	6.75	5.9	12.6	9.3	6.3	32.2
No. 2	Grain		5.10	4.75	6.9	6.6	6.0	9.10	9.05	6.7	26.
No. 2	Grain		5.25	4.9	6.7	6.75	6.05	10.4	9.75	6.55	32.8
No. 2	Flesh		3.7	3.10	16.2	3.97	3.28	17.4	4.15	3.47	16.4
No. 1	Grain	75	6.7	6.3	6.0	8.45	7.75	8.28	10.3	8.7	16.0
No. 1	Grain		6.2	5.9	4.85	8.05	7.5	6.83	11.1	8.9	19.8
No. 2	Grain		5.75	5.6	2.6	7.3	7.25	0.68	10.2	9.2	9.85
No. 2	Grain		5.9	5.65	4.23	7.5	7.2	4.0	10.5	9.1	12.9
No. 2	Flesh		4.82	4.5	6.63	5.15	4.83	6.2	5.55	5.2	6.3
No. 1	Grain	100	7.35	7.15	2.7	9.2	8.9	3.26	11.5	11.0	3.9
No. 1	Grain		6.95	6.75	2.9	8.85	8.55	3.4	11.5	11.0	4.3
No. 2	Grain		6.6	6.47	2.0	8.27	8.10	2.10	11.2	10.5	6.0
No. 2	Grain		6.6	6.45	2.3	8.35	8.2	1.8	11.6	10.9	6.10
No. 2	Flesh		6.0	5.9	1.7	6.45	6.35	1.5	6.98	6.9	1.1

drive for the same load. Obviously any comparisons on this type of belt must be made at 3 per cent slip or more. With the lower-capacity belts, such as the flesh side of belt No. 2, creep alone persists only up to about 0.5 per cent slip beyond which point true slip commences and the curves separate. A good comparison of the two drives with the flesh side against the pulley may be made at 1½ to 2 per cent slip.

Table I gives the horsepower transmitted at 1.5 per cent, 2 per cent, and 3 per cent slip at each tension for each belt tested on the horizontal and vertical drives, including those made in connection with the angular drive tests. These values were picked from the horsepower slip curves, all of which are not included here.

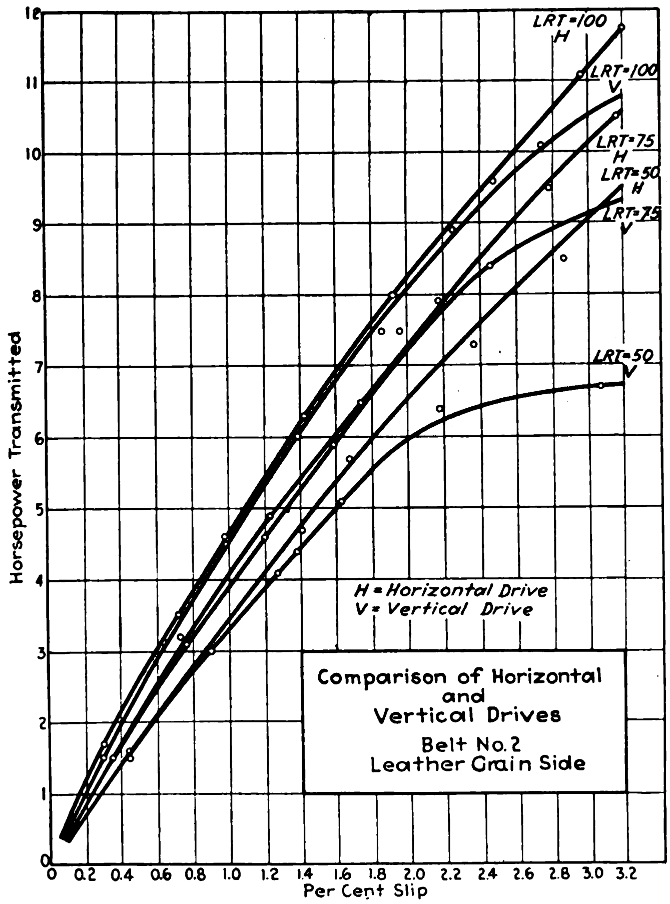
Most of the conclusions from this table will be based on the horsepower transmitted at 3 per cent slip. At the medium tension (75 lb. *L R T*) with the grain sides of the two belts to the pulley, the horizontal drive transmitted an average of 14.6 per cent more power than the vertical drive; in the one flesh side comparison the difference was 6.3 per cent. Since 75 lb. is slightly above the average tension, perhaps it would be well to examine the results at 50 lb. *L R T*. Here the horizontal drive with the grain side to the pulley gave an average of 28 per cent more power, and a superiority of 16 per cent in the one flesh side comparison. After weighing these results in conjunction with those from several tests not given here, our general conclusion is that a leather belt for a vertical drive at the test center distance (7 ft. 6 in.) should be about 12 per cent wider than for a corresponding horizontal drive. The difference at other center distances is given in Table II.

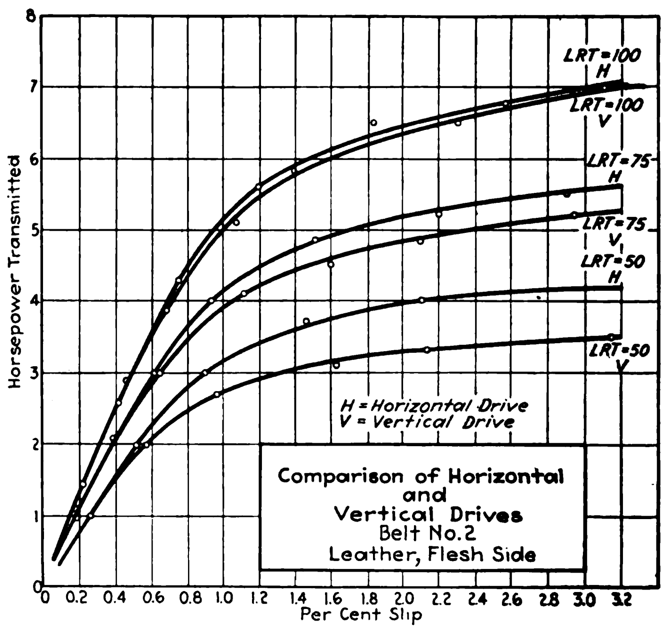
The problem of the center distance is of considerable importance because the transmission capacity of a vertical belt does not increase with the center distance as does that of a horizontal belt. The operation of a vertical belt is the same as a horizontal belt in that as the load increases, the belting material under tension on the tight side is worked over to the loose side, which reduces the tension on this side. However, the loose side of a horizontal belt can take care of additional length by sagging without much reduction of the loose side tension, while the loose side of a vertical drive must take care of it by shortening up an amount equal to the additional length from the tight side.

A point is soon reached with the vertical belt, when any further shortening of the loose side would result in zero tension on this side, and further increase in load or tension would cause the belt to fall away from the lower pulley. This is the absolute theoretical limit of transmission for any vertical drive. Practically, when the slack side tension is reduced to a certain value

Table III—Horsepower Transmitted at 3 Per Cent Slip on the Angular Drives

General Data			67½ Deg. Drive			45 Deg. Drive		
Belt No.	Chart Fig. No.	LRT Lb.	T_1-B Hp.	T_1-A Hp.	Diff. Per Cent	T_1-B Hp.	T_1-A Hp.	Diff. Per Cent
1	6 & 7	50	7.2	6.75	6.25	9.13	7.75	15.1
1	6 & 7	75	9.7	9.35	3.60	12.0	10.45	12.9
1	6 & 7	100	12.15	11.20	7.80	12.8	11.50	10.1





Figs. 4 and 5—The difference in transmitting capacity of horizontal and vertical belts is well shown here.
The different results obtained by driving with the grain (Fig. 4) and flesh (Fig. 5) sides next to the pulley clearly indicate the advantage of using the grain side.

the belt slips badly, and this is the actual limit of transmission. It is obvious that, since the horizontal belt can compensate for the extra length by sagging on the loose side while the vertical belt can not, the horizontal belt ought to transmit more power.

From the above analysis, it can be readily seen that the capacity of a vertical drive depends on its ability to shorten up on the loose side. If the center distance is doubled, then there will be twice as much extra length passing over to the loose side, for any given load, but there will also be twice as much shortening of the loose side, so the slack side tension will remain the same. It follows, therefore, that the power transmission of a vertical belt is independent of center distance, except for the effect of the additional weight of a longer belt, which is practically negligible.

As the horizontal belt capacity increases with the center distance, while the vertical belt capacity does not, there will be a greater percentage difference between the power transmission of the two belts at long center distances than at short ones. Using the relation between the center distance and transmission capacity of a horizontal drive given in Fig. 9 as a guide, Table II has been prepared to show approximately what the rated capacity difference of the two drives would be at other center distances. The right-hand column gives the percentage difference based on the horizontal belt rating, which is greater. Although Table II can be used for belt design work, this information may be applied more easily to actual belt problems by using the method of design and the necessary charts given later in this article.

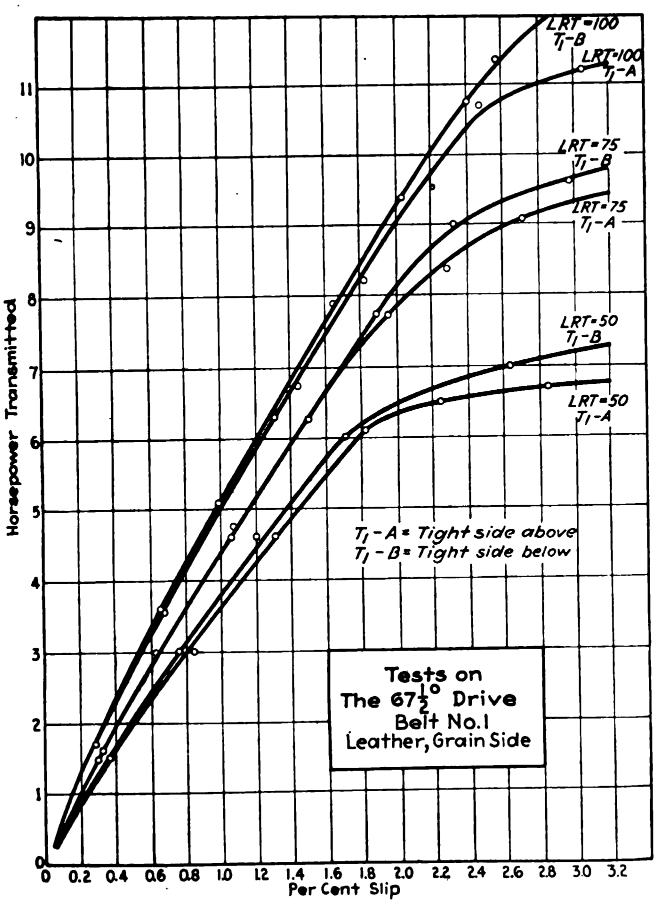
It is apparent that the vertical belt is more sensitive to tension changes than the horizontal belt. The charts reproduced here as Figs. 4 and 5 show a greater reduction in transmission capacity with the vertical belt as the tension is reduced. The gradual drop in tension of a factory belt would cause a similar drop in capacity, and probably it would have to be retightened more often than a horizontal belt to maintain its rated capacity.

Some of the tests on the angular drives at 67½ deg. and 45 deg. with the horizontal were a little confusing, because certain belts at the 100 lb. *L R T* transmitted more power on the 45-deg. drive than they did on the horizontal drive. Later a careful check at this tension indicated that there is little difference in the transmitting characteristics of the two drives. At the two lower tensions the transmitting abilities rated in the following order in most of the tests: first, horizontal belt; second, 45 deg. belt; third, 67½ deg. belt; and fourth, vertical belt.

Two sets of curves, Figs. 6 and 7, illustrate the general characteristics of the angular drives. In every case, more power was obtained with the tight side of the belt below but there was less difference between these two conditions at 67½ deg. than at 45 deg. Thus, as the vertical is approached, the difference becomes less, and reaches zero at the vertical. Another general characteristic which can be seen from these curves is that as the tension is increased, the 45-deg. and 67½-deg. drives perform more nearly alike. This is in accord with a similar conclusion reached concerning the horizontal and vertical drives and it applies to all the drives.

The values in Table III, which compares the power obtained from the 67½-deg. and 45-deg. drives with the tight side above and below, were taken from Figs. 6 and 7.

Figs. 6 and 7—The effect of angular drives on transmitting capacity, as shown by these charts, is discussed fully on this and the following page.



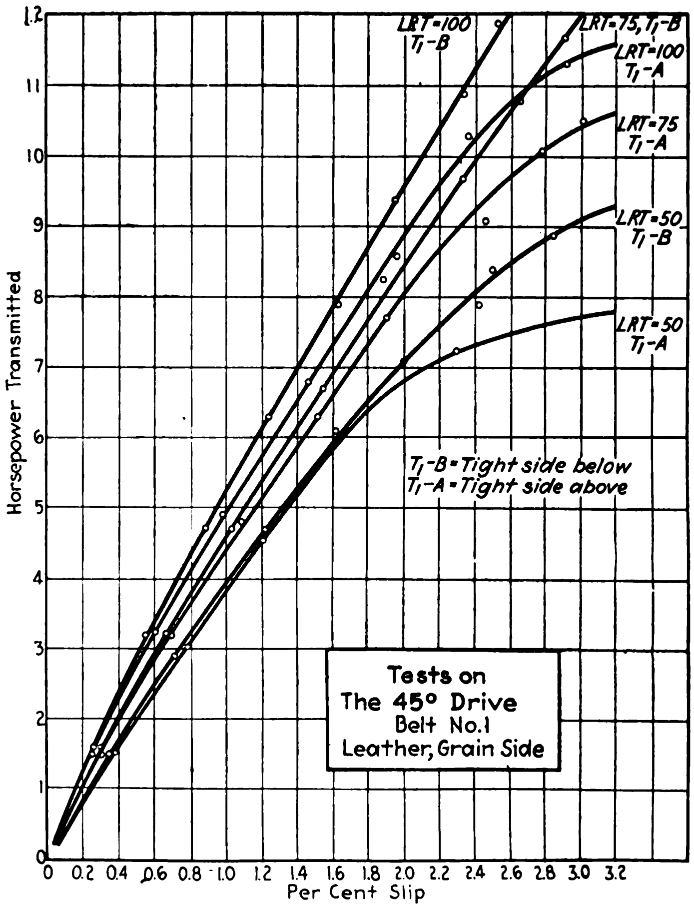


Table III can be studied more easily than the curves and if desired it can be compared with Table I on horizontal and vertical belts. Under average tension conditions a 67½-deg. drive, having its tight side below, will transmit about 6 per cent more power than with the tight side above. The difference will remain about the same for all ordinary center distances, say up to 20 ft. On the 45-deg. drive this difference in transmission is about 12 per cent for the center distance used, but it will increase some with longer center distances, probably about the same as with a horizontal drive.

For all practical purposes the 45-deg. drive may be rated the same as the horizontal drive, if the tight side of the belt is below, while if the tight side is above, the rating for a 45-deg. drive should be a little less than for a corresponding horizontal drive. The 67½-deg. belt with the tight side below should be rated about halfway between the horizontal and vertical drives, and when the tight side is above, the rating ought to be that of a similar vertical drive.

The results and conclusions from these experiments have been correlated with the curves for belt design which were given in the previous article and are repeated here as Figs. 8 and 9. The following recommendations are made for the design of vertical and angular drives by this method.

(1) For vertical drives, and for angle drives between the vertical and 45 deg. with the *tight side above*, use a correction factor of 0.765 multiplied by the correction factor for pulley size from Fig. 9. The product of these two factors should then be multiplied by the horsepower ratings from Fig. 8 to obtain the corrected horsepower per inch of width. No correction factor is needed for center distance.

(2) For angle drives with the *tight side below* between the vertical and 67½ deg., use the method given above under *(1)* above.

(3) For angle drives with the *tight side below* between 67½ deg. and 45 deg. use a constant correction factor of 0.815 instead of 0.765 and proceed as directed under *(1)*. No correction factor for center distance is needed as the figure 0.815 takes its place.

(4) For angle drives between 45 deg. and the horizontal, with the tight side above or below, use the method of design as explained at length in the caption in connection with Figs. 8 and 9.

Some may have doubt as to the accuracy of work done on belts as narrow as 1 in. and the reliability of assuming that results obtained on such narrow belts are applicable in direct proportion to the width on wider belts. Some time ago we made a careful investigation of the relative capacities of belts of different widths and found that the transmission capacity varied directly with the width of the belt. Furthermore the author has since had many opportunities to check this law with leather and other kinds of belts and has always found it to be correct. The absorbing dynamometer and tension scale are smaller and more accurate than those on larger apparatus. Therefore, we are fully convinced that the conclusions drawn from this work are reliable.

Figs. 8 and 9—These curves are used in conjunction to obtain correction factors for determining allowances, because of center distance, pulley size and whether the tight or loose side of the belt is on top, when laying out a belting installation.

In the use of these charts the following precautions must be observed: *(a)* These charts are to be used only on horizontal or approximately horizontal drives. *(b)* Do not use Fig. 8, at left, without the correction from Fig. 9, at right. *(c)* The diameter of the larger pulley should not be more than six times the diameter of the smaller one. To use these curves, with these three points in mind, proceed as follows:

(1) Find the correction for center distance from one of the two center-distance curves, depending on whether the tight side is above or below. If the center distance is greater than 25 ft., use the correction for 25 ft.

(2) Find the correction for pulley size from the pulley-size curve, Fig. 9, using the diameter of the smaller of the two pulleys. If both pulleys are larger than 36 in. in diameter no correction is necessary.

(3) Choose the curve, Fig. 8, at left, corresponding to the desired weight of belt, and take from it the horsepower per inch of width according to the belt speed used.

(4) Multiply the result of *(1)*, *(2)* and *(3)* together to get the corrected horsepower per inch of width.

(5) Divide *(4)* into the total horsepower to be transmitted to get the correct width of the belt.

As an example, suppose a 10-in. pulley running at 1,000 r.p.m., giving a belt speed of 2,600 ft. per min., is to transmit 15 hp. to a 36-in. pulley at a center distance of 8 ft. Assuming the tight side is below, what size of heavy single belt is required? Carrying the computations through in the same sequence as indicated, the procedure is as follows:

(1) The correction factor for 8 ft. center distance with T_1 (the tight side) below is obtained from Fig. 9 and equals 0.87.

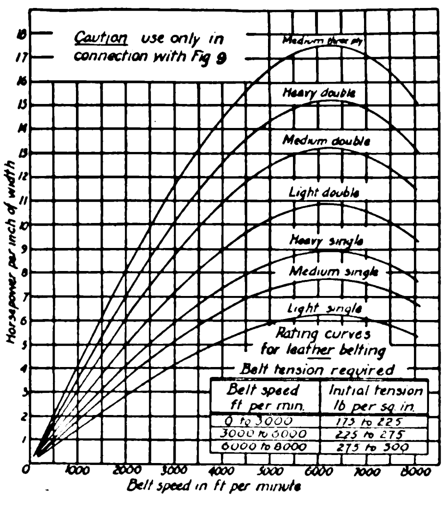
(2) Correction factor for 10-in. pulley size from Fig. 9 equals 0.853.

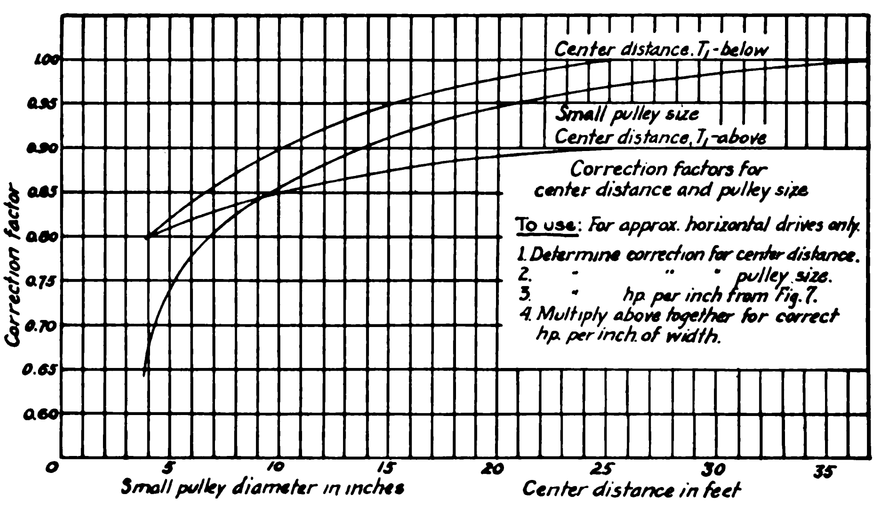
(3) Horsepower per in. width, from Fig. 8, at belt speed of 2,600 ft. per min. for heavy single belts=5.25.

(4) Multiplying, 0.87×0.835×5.25=3.9 horsepower.

(5) Divide 15 by 3.9=3.85, width of belt. Therefore, use a 4-in. heavy single belt.

When the width of belt comes out an uneven size such as 3.85 in. the next larger size should always be chosen. A table of the initial tensions required for different speeds is given in Fig. 8. The tensions are given in pounds per square inch of cross-sectional area per strand of belt. The cross-sectional area is obtained by multiplying the width times the thickness, so a belt 4 in. wide and 0.2 in. thick would have a cross-sectional area of 4×0.2=0.8 sq. in. If the recommended tension is 175 lb. per sq. in., the tension per strand on this belt would then become 0.8×175=140 lb.





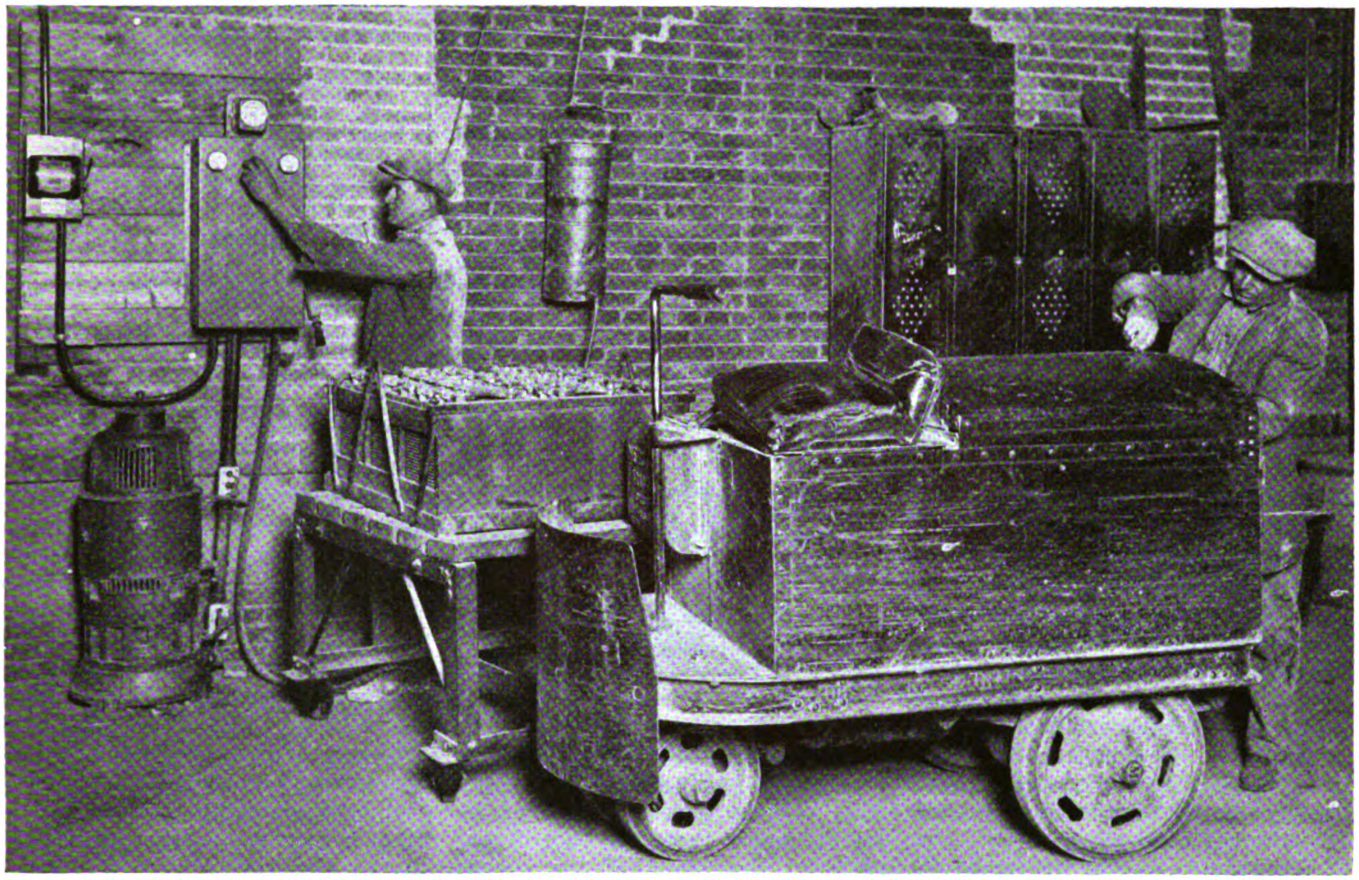


Fig. 1—A single unit charger is used continuously at this plant.
This Mercury tractor is provided with two batteries, one of which is on charge while the other is in use. This permits 24-hr. operation of the tractor. Note the convenient caster-mounted table for receiving the Edison battery as it is pulled out of the tractor and for holding it during the charging process. The interior of the control panel is shown in Fig. 8 and the connection scheme for it is shown in Fig. 9.

Some of the factors to be considered when

Selecting Storage Battery Charging Equipment

with a discussion of the charging requirements of lead and alkaline batteries, and characteristics of equipment best suited to industrial use

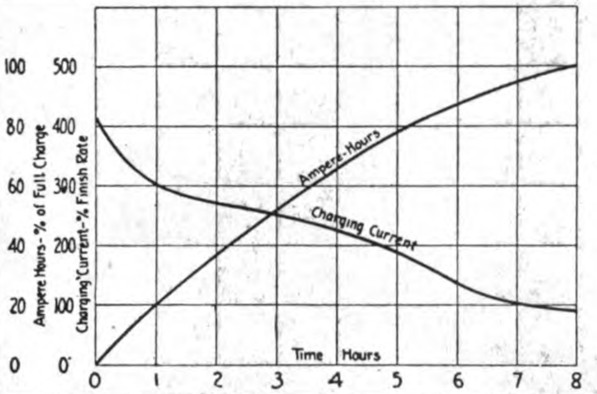
BY JOHN H. HERTNER
President, The Hertner Electric Company, Cleveland, Ohio

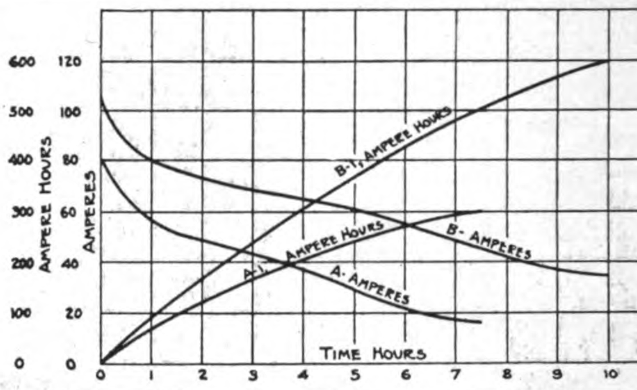
FROM late in the nineties until about ten years ago the number of electrically-driven passenger carriages in use gradually increased in number. Since that time, however, there has been a diminution in their use until they have all but disappeared.

In the meantime the industrial tractor and truck have demonstrated their worth. From a comparatively small number in 1915, the number of trucks and tractors in use has steadily grown and they are establishing new fields of usefulness in places where only a short time ago manual labor was ineffectively employed at probably ten times the cost. Go into the plant of an industrial truck manufacturer at any time and you will be able to see a new model, specially designed to replace hand labor and for doing some special work more quickly, more effectively, and more cheaply.

The electric road truck, too, is making steady progress. Although its advance has not been so rapid as that of the industrial type, the electric road truck is considered superior to the gasoline truck for hauling that does not involve long distances at high speeds. On account of its ease of handling, the electric commercial truck will often accomplish much more work in a given time.

During the period when the pleasure car was the principal user of charging current the matter of battery charging was on a much less scientific basis than it is today. The car was generally charged either at home or in one of the many public garages. If charged at home, the owner put the plug into the receptacle on the car, closed the switch and permitted the unit to take care of itself. The charging rate generally dropped to a point so low that if it remained connected beyond the proper point of battery charge, the cells were not injured nor did the owner inquire about the extra energy consumed. As a rule the time available for charging was more than ample, so that the rate from start to finish could be low. Usually the battery could be charged for 12 hr. The car that was run





late in the evening was generally not wanted until noon and the one that had to go out early in the morning had not been used late the evening before. If the car was charged in a public garage, the same conditions held except in those places where an attendant made the rounds periodically, taking gravity readings and readjusting the ballast resistance. If the car was not properly charged it was considered simply as an unavoidable accident which was to be expected.

With the coming of the industrial truck and the passing of the electric pleasure car, conditions are somewhat different and the need of reliable charging apparatus and methods has become more imperative. A truck held out of service unexpectedly may disturb the output of an entire factory and it is essential that every effort be made to avoid any tie-up in truck operation.

The thing that gives life to the truck is the battery, and the battery in turn depends for its life upon the charging equipment. Both alkaline and lead batteries, each of which has its advantages, are being used in increasing numbers. The two types must, however, receive considerably different treatment in charging. To get the best results, the alkaline type must be charged at an ampere rate about the same as its average working discharge rate. The lead battery, on the other hand, demands a charging rate that

Figs. 2 and 3—Performance of charging equipment for lead battery service.

In Fig. 2 are shown the charging current curve and ampere-hour curve for a single-unit charger. Fig. 3 shows the curves for a dual-unit charger. *B* and *B-1* are the charging current and ampere-hour curves, respectively, when the unit is charging two batteries simultaneously. *A* and *A-1* are the performance curves after one battery has been cut out.

is quite low at the finish, but which may be extremely high at the start. This rate is sometimes defined by the statement that "the rate in amperes at any stage of the charge may be as high as the ampere-hours still remaining to be put into the battery." Hence, since the rating of a battery is generally given as a certain ampere rate over a period of from four to six hours the starting rate of charge may be from four to six times the normal discharge rate.

At first glance, it would appear that for charging a lead battery a constant-potential source would be preferable, because during the charging process there is a rise in battery potential, dependent on the charging rate and other factors, which may be roughly set at 15 per cent and which on a constant-potential source will aid in reducing the ampere rate as the battery becomes charged. This is just what a lead battery should have, but it is not suited for alkaline batteries which, as above stated, should have a uniform charging rate and, therefore, a constant-current source of charging energy.

Under these conditions several systems of charging have sprung up in an attempt to make existing constant-potential sources of current fit the needs of the battery.

Street trucks were largely standardized to fit 110-volt service with about 40 cells of lead battery or 60 cells of alkaline battery so that only a small amount of the energy used in charging would be wasted in the ballast resistance. When the

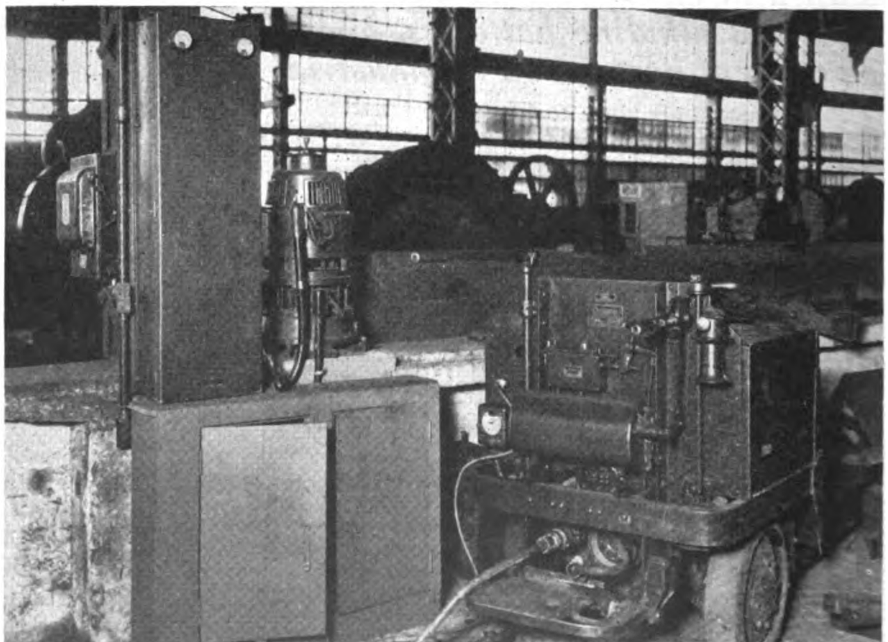
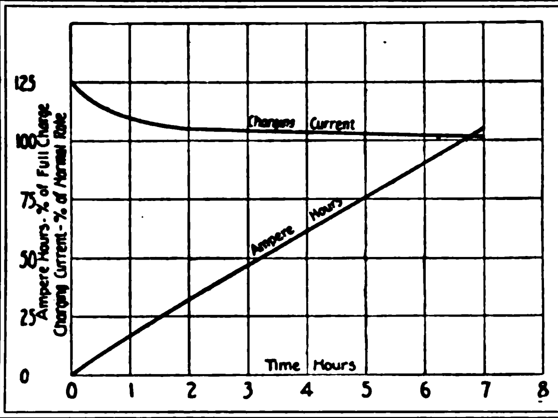
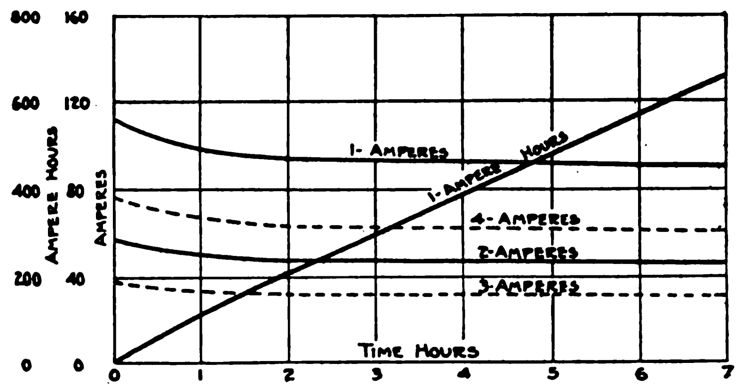


Fig. 4—Dual unit charger for use on industrial trucks.

This is an installation of Hertner charging equipment in the plant of the Whiting Corporation at Harvey, Ill. It is capable of charging two sets of 12-cell, 21-plate batteries simultaneously and is shown charging an Exide Ironclad battery in a Baker R & L lift truck. Notice the Sangamo ampere-hour meter mounted on the front of the truck so as to give the driver an indication of the condition of the charge in his battery.





Figs. 5 and 6—Different characteristics are required of the charging equipment for alkaline batteries.

Fig. 5 shows the characteristics of a single-unit charger, while Fig. 6 is for a dual-unit charger. The dotted curves in Fig. 6 show the result of setting the field regulator to charge simultaneously two batteries of unequal capacity and requiring different charging rates.

industrial truck and tractor were introduced these standards were not followed, for lower voltages were adopted. This may be traced to a number of causes.

First, one of the earliest applications of industrial trucks was for the moving of baggage in railway stations. Here batteries which are standardized at 24 volts on discharge are also used in car lighting and it was convenient to use the same charging facilities for both types of batteries.

Second, with the smaller watt-hour capacity required in the industrial truck it was found advantageous to use fewer cells, rather than to retain the same number of cells and use a smaller size. With the same watt-hour capacity the larger cells occupy less room; and space is at a premium in industrial vehicles. As an illustration compare 40 cells of 7-plate Exide Ironclad battery with 20 cells of 13-plate Exide Ironclad battery. Both batteries are rated the same in watt-hours, being 7,560 on a 4½-hr. basis, and can consequently do the same work. As to the space occupied, however, the 7-plate battery occupies approximately 14 per cent more space than the 13-plate unit, weighs 11 per cent more, and costs more. Similarly with the Edison battery, comparing 40 cells of the size A-4 with 20 cells of the A-8 size each has a capacity of 7,200 watt-hours on a 5-hr. basis, but the 40 cells of A-4 can be put into four standard crates of 10 each while the 20 cells of A-8 can be put into four standard crates of 5 each. These crates will be about 12 per cent shorter than the A-4 crates, but of the same width and height. The A-8 battery weighs somewhat less and also costs less.

Aside from this, there is a decided advantage in the use of the lower voltage in that there is less electrical leakage which, particularly in the case of some of the older assemblies of lead batteries, was often quite troublesome. Offsetting this, however, with the lower voltage there is the necessity of using heavier wiring in order to avoid excessive copper losses, for with the voltage cut in two the current is doubled so that the resistance of the wiring must be quartered, which means that the copper cross-section must be increased fourfold. In addition, this lower voltage requires larger commutator surface and the size of the controller fingers must be increased, both of which add to the expense. Apparently, however, these disadvantages are more than balanced by the advantages.

No definite standard voltage for industrial truck use has been adopted to date and the possibility of such standardization seems remote. Where the service is fairly light and where more speed is required it is an easy step to substitute 15 smaller cells for 12 cells of a certain size, thereby giving the vehicle the required speed, and although this cuts down the mileage per charge, yet it increases the daily radius because of the decreased running time per trip. This, of course, changes the charging conditions.

As matters stand today most industrial trucks operate on from 6 cells of lead-type battery or 12 cells of Edison alkaline battery as a minimum, to 24 cells lead or 42 cells Edison as a maximum, with any one of a number of intermediate points.

Under such conditions charging from 110-volt direct-current power is extremely inefficient, unless the cost of power need not be seriously considered. If for example, 12 cells of 15-plate Exide Ironclad battery are to be charged the actual energy required to fill them would be about 7,000 watt-hours which, at a cost of five cents per kw-hr. would cost 35 cents. However, the energy wasted in the ballast rheostat is approximately three times as great and would cost approximately 95 cents, which is quite an item. If, on the other hand, the power cost is only one cent per kw.-hr. the cost of the useful energy put into the battery is seven cents, while the energy lost in the ballast resistance is reduced to 21 cents. Were the line service 220 volts the losses would be more than double, totalling $2.20, approximately.

Further, when thus charging through a fixed resistance, the current would be of almost constant value. This is apparent since the current would be determined by the difference between line and battery voltage, and on a 110-volt line and a 12-cell battery this would be approximately 110—(2.15×12)=84 volts at the start and 110—(2.6×12)=79 volts at the end of the charge, or a total drop of only 8 per cent.

In order, then, to charge a lead battery within a reasonable time, keeping the finish rate within safe limits, it is necessary to vary the resistance either manually or by some automatic means. The time-honored rule, which was generally found engraved on the nameplate of the battery, was to charge at a rate which, if held continuously, would completely charge it in about 5 hr. until active gassing began, when this charging rate was reduced to about one-third of the former rate.

This is automatically accomplished through the use of an ampere-hour

meter furnished with an extra gassing contact which operates a breaker so as to increase the resistance in the circuit when the charge reaches the proper stage and thereby cuts the current to the correct finishing rate. When the battery is charged it is generally disconnected by the opening of a second breaker operated by a corresponding contact on the meter.

This is, of course, only approximately correct. For a proper charge, in order to fill the battery as quickly as possible with least amount of gassing and heat, the charging rate should fall from the start until the finishing rate is attained. Rapid gassing indicates a loss of energy, for the gas given off is the result of the decomposition of the water of the electrolyte, instead of having the current absorbed in altering the chemical condition of the plates. Incidentally, rapid gassing has the effect of loosening the active material and shortening the life of the plates.

For charging the Edison battery, a direct-current source requiring a large voltage drop in the ballast resistance is admirably suited. For example, with 21 cells of Edison battery to be charged from a 110-volt line, the initial voltage of the battery would be about 33 volts and the final voltage would be 38 volts, with a current drop from start to finish of only about 8 per cent. This, however, does not alter the fact that such charging is extremely wasteful of electrical energy and the loss is serious where the cost of power is at all high.

In all cases where alternating current only is available it is necessary to use a transforming device. A very dependable type of such device for batteries of the size under consideration is the motor-generator unit. All power lines are subject to disturbance and in the case of alternating-current service there are possible variations both of voltage and frequency, and the characteristics of a motor-generator set are such as to transmit to the least extent any such disturbances that may occur; hence the direct-current output is less affected than if a rotary converter or other device were used.

The manufacturers of both the lead and the alkaline types of batteries recommend the use of the so-called constant-potential and modified, constant-potential systems for charging. In the case of charging lead batteries, the generator potential is maintained at 2.3 to 2.4 volts per cell and the battery is thrown onto the line without ballast resistance. The initial current is high and some care must be exercised to meet the needs of the room temperature, and consequently that of the battery. Individual batteries also show differences in finish voltage due to differences in age, density of electrolyte, type of plate, and other similar conditions.

With the alkaline battery there is no real equivalent to the above, because a ballast resistance must always be used where constant line potential is applied. It might be added here that when a lead battery has been allowed to sulphate, it is necessary to use a higher voltage to break down the resistance of the plates and 2.4 volts per cell is not a sufficiently high voltage for this duty. This, along with the facts already mentioned, makes the modified, constant-potential system more desirable.

With the modified, constant-potential system a ballast resistance is used, the amount of which is dependent on the number of cells in series, the size of the cell, and the time available for charging. These items also determine the line voltage to be applied. From the constant-potential system on one extreme, with no ballast and a short charging time, it is possible to go to an extremely high line voltage with a large ballast resistance, a low charging rate, and long time of charging. A modified, constant-potential system provides a means of selecting such a charging time as is available and satisfactory, and choosing the proper line voltage and ballast resistance.

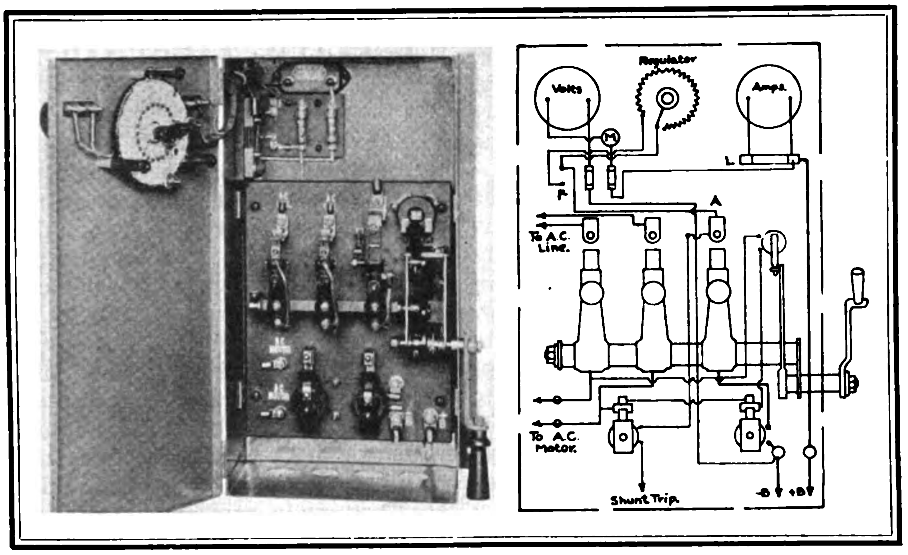
Under average conditions a charging voltage of 2.6 volts per cell is quite satisfactory for any lead battery and the manufacturers have worked out a table of ballast resistance values to be used to obtain the proper finishing rate for various types and sizes of cells.

With the alkaline battery, as was stated, there is no real constant-potential charging, for ballast resistance must always be used. One plan recommended by the Edison Storage Battery Company is to use a variable resistance that is hand operated, being adjusted from time to time so as to keep the current rate substantially constant.

Using the modified, constant-potential system the Edison Storage Battery Company recommends starting the charge at about 166 per cent of normal and finishing at about 66 per cent of normal, making the starting current about 2½ times the finishing current. It must be remembered, however, that this same ratio is not to be followed regardless of

Fig. 7—It is now standard practice to mount an ampere-hour meter on each industrial truck.

This meter shows the amount of charge remaining in the battery, also, while the battery is on charge, it shows the amount of charging yet required and automatically shuts down the charging equipment when the battery is fully charged. This illustration shows a Sangamo ampere-hour meter mounted on a Mercury tractor.



Figs. 8 and 9—Automatic control panel for a single unit charger.
Fig. 8 shows the interior of the panel illustrated in Fig. 1, while Fig. 9 shows the connection diagram when looking at the panel from the front. The three large contactors in the center are operated from the handle on the outside of cabinet. The right-hand contactor *A* in Fig. 9 connects the battery to the generator and starts the motor-generator set. The two left-hand contactors are then closed, thereby connecting the motor to the line after which, charging of the battery begins. The rheostat at the top regulates the generator field current, which in turn controls the charging current. Two relays are shown at the bottom of the panel, the one on the right is an overload relay, while the one on the left operates in conjunction with the trip circuit from the ampere-hour meter on the truck.

absolute values. In other words, the battery should not be charged at a rate beginning with, say, the normal discharge rate and finishing at 40 per cent of this rate, as such a finish is too low for the best performance.

The Edison battery when fully charged requires a charging potential of about 1.84 volts per cell. The recommendation of the manufacturer is to insert an amount of ballast resistance per cell, dependent on the size of the cell, which will give a drop of 0.10 volt per cell or a total charging voltage per cell of 1.94 volts with 66 per cent of the normal current flowing. Hence, with 21 cells in a battery, the line voltage for charging should be about 41 volts.

With either type of battery and under practically all conditions it will be found that unless feeder, switch, and other resistance drops are in some way recognized, the current will always be less than supposed.

There are many places where direct current is not available; also, it is usually wasteful to use it because in most cases the number of cells under charge is so small that the charging voltage uses only a small part of the potential available and the larger part of the energy is lost. Hence, it becomes more and more apparent that a motor-generator set or, in the case of direct-current service, a dynamotor, affords an economical method of converting the service to the proper charging voltage.

Equipment large enough to carry all the batteries to be charged at one time should be provided. The equipment should be arranged so that each battery will have a ballast resistance, a circuit breaker and, if the charging is to be automatic, an ampere-hour meter or its equivalent. In addition to this, it is customary to add a voltmeter and ammeter so arranged that all necessary readings may be made on each battery as the charge progresses, as well as an additional ammeter to read the total current delivered by the generator. Circuit breakers with the usual features of overload protection are usually provided, and the motor is started through a compensator with overload and no-voltage release.

When it is desired to make the charging system automatic, an ampere-hour meter affords a very reliable means of terminating the charge. In this connection, the circuit breaker should be provided with a shunt-trip attachment having auxiliary contacts to open the tripping circuit and thus avoid arcing in the ampere-hour meter contacts. It is best to have each truck equipped with an ampere-hour meter, for with this arrangement the meter shows while on discharge how much energy has been taken out and permits the operator to judge about how much is still remaining. When the battery is again put on charge the current will cause the hand of the meter to gradually swing back to zero, which is the full position. On arriving at this point a contact is made which trips the circuit breaker and thereby stops the charging operation. The meter is so arranged internally that more energy is required to bring the hand back to zero or the charged position than it took to bring it to the point of discharge; in this way it takes care of the fact that more energy must be put into a battery than can be gotten out of it. An installation of a Sangamo ampere-hour meter on an industrial truck is shown in Figs. 4 and 7.

Charging equipment can be obtained for charging each battery separately, or the equipment can be arranged with multiple circuits for charging more than one battery at a time. Several advantages and disadvantages are incidental to the use of a multiple-circuit plant. A unit of this kind is compact and is usually somewhat cheaper in first cost than if a number of smaller, single-circuit sets were used. On the other hand, such a unit is generally only partly loaded so that its efficiency is not at its best. It dissipates considerable power in ballast resistance, which again means loss and inefficiency. It is generally more expensive to install on account of the more intricate switchboard and wiring, and in addition it provides no safety factor; that is, if the unit is out of commission the charging current must be secured elsewhere, if the trucking and hauling service is to be continued.

By dividing the charging capacity required into smaller units, each capable of serving one or two batteries at a time, some very decided advantages can be obtained. These small units will run on a fairly good load factor, use no ballast resistance and are thus more efficient electrically. They make a more flexible unit in that if a part of the trucking equipment is to be used at a distant part of the plant it is possible and generally advisable to move the necessary capacity of charging equipment to a point convenient to the temporary location of the trucks. There is likewise no possibility of the trucking service being suspended, for one unit down out of a number will not seriously cripple the charging service.

It might be added that with a number of smaller units, repairs will be made more promptly and more thoroughly, for this will remove the temptation of permitting the equipment to run on a temporary repair.

As against the installation of a single charging unit on the one hand and the use of small units on the other, there is the possibility of having two units both of which can be thrown in parallel, using a common switchboard and one set of buses. This obviates the danger of complete breakdown, but does not materially improve the efficiency for it does not eliminate the need of ballast resistors, nor does it improve the flexibility of the system, as the two units cannot well be separated.

The third alternative already referred to, is to install either dual or single plants so that at most only two batteries can be charged at one time from any one of them. Such machines can be arranged to be started from the battery and by means of a Sangamo ampere-hour meter or other device will shut down automatically when the battery is fully charged. Such units have the further advantage of being designed to take care of the particular type of battery, whether lead or alkaline, for which they are intended. A single unit charger in use on an Edison battery is shown in Fig. 1. A dual unit charger is shown charging an Exide lead battery in Fig. 4.

In Fig. 2 are shown the performance curves of a single unit charger for a lead battery. Note that the charge starts at a fairly rapid rate and tapers as it proceeds, to a safe finish. The time of charging is based on an 8-hr. period.

Fig. 3 shows the performance curves of a dual charger for lead batteries. Here *B* and *B-1* are the ampere and ampere-hour curves, respectively, with two batteries on charge. Should one battery become charged ahead of the other, which often happens because of only partial discharge, this battery is automatically disconnected and the plant readjusts its current to the rate required for the remaining battery, as shown in curves *A* and *A-1*. A view of the charger just described is shown in Fig. 4.

In Fig. 5 are shown the performance curves of a single-circuit unit designed for charging Edison batteries. Note the uniformity of the current after the first 2-hr. period. The initial drop is due to the warming up of the generator; after this is accomplished the current output will remain constant indefinitely. This type of charger is illustrated in Fig. 1. The control panel and wiring connections are shown in Figs. 8 and 9.

Fig. 6 shows the performance of a dual plant for charging Edison batteries. The curves that are numbered *1* are of amperes and ampere-hours with two batteries in circuit. The completion of the charge to either battery and its automatic disconnection, drops the charging rate for the remaining battery to curve *2*. The dotted-line curves indicate the result of setting the field regulator to accommodate the charging of two batteries of unequal capacity, such as an A-4 and an A-8 battery.

The entire capacity of the unit can be used to boost a single battery at the full plant capacity, if desired.

Automatic features can be provided to suit conditions. As a rule automatic cutting off of each battery when filled is called for, as well as shutting down of the plant as soon as charging is finished. Besides this, overload protection is generally demanded. As these units are started from the storage battery that is about to be charged no compensator is required and no line disturbance is created at the time of starting. This type of control and the connection scheme for it is illustrated in Figs. 8 and 9.

As to protection of the outfit in cases of line failure, there are several means of taking care of such an emergency. If the failure is of short duration it is generally advisable to permit the unit to float on the battery. This is, of course, impossible in the case of a large, multi-pole generator where the no-load current necessary to keep running is a serious drain on the battery and where the flat compound winding of the generator is likely to cause reversal of polarity and a consequent runaway of the machine. On a small unit this plan is very successful.

A second plan is to open the direct-current circuit by means of a reclosing breaker allowing the generator to come to rest. On resumption of service the motor will start, which on a small unit can be safely done without a starter.

A third plan involves the operation of automatically restarting the motor of a unit which has completely disconnected itself on line failure. After automatically restarting, the direct-current circuit closes as soon as the generator voltage is correct.

Electric Heat for Industrial Use

(Continued from page 159)

lining stands up well under the comparatively moderate temperatures to which this material is exposed. The electric furnace shown in Fig. 7 was installed in August, 1919, and has been in operation continually at temperatures from 1,400 deg. to 1,650 deg. F. since that date. The service is the heat treatment of steel in a tool and die shop. The original resistors are still in use and the maintenance cost of this furnace has been negligible, consisting mainly of an occasional renewal of the brick hearth which gradually wears out due to the sliding of charges of material on its surface. Metal hearths —a nickel-chromium alloy—are now generally used in furnace construction in place of the brick hearth.

The cost of the services of operators for plants using electric heat are always favorable. Good working conditions are desirable. Surroundings which promote the well being of the workmen are recognized as an economy in their promotion of both efficiency and contentment. The cleanliness of the heat process can be readily seen from Fig. 2. The confirming comments of operators on these points as regards electric heat are of interest and well worth considering.

The testimony of many users of electric current for heat treatment processes is that because of the uniformity of this method of heating there are but few defective pieces in the output of the heat treating plant and that this alone often justifies the choice of the electrical method of heating. A rejected part represents a loss of labor often a loss of material and a loss of service or profit from the sale of the part. As an incidental factor it is found that this uniformity of output materially reduces the time and cost of inspection.

The quality of the work produced in a heating chamber depends upon the quality of the charge of material, the skill of the operator and upon even heating and close control of the temperature of the work. Assuming the first and providing the last named heating chamber conditions, the entire attention of the operator can be given to the object of his efforts and both rate of production and quality of product are benefitted thereby.

Things that may happen when

Changing Right-Hand Coil Windings to Left-Hand

together with details of windings made by machine and by hand, and ways to correct reversed direction of rotation and other difficulties

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TO TELL when right-hand or left-hand coils are used, face the commutator end of the armature and inspect the coils above the shaft. If the starting and bottom leads of a loop winding, or the finishing leads of those windings having the wire cut at the end of each coil, are at your right, then the coil is right-hand. If the leads as above mentioned are at your left, the coil is left-hand. Right-hand coils are shown in Fig 1*A* and left-hand coils in Fig. 2*A*.

WITHOUT considerable experience in rewinding small motors, it is not always clear just what happens when a right-hand coil winding is changed to a left-hand coil winding, in the case of direct-current and universal-type motors used in small drills, vacuum cleaners and the like. In what follows the essential details of these windings will be explained, with the conditions that result in changes in the direction of rotation. The effects of reversed rotation on the fields of straight series machines and on the fields of universal motors with a non-compensating winding and with a compensating winding will also be explained, with instructions on how to correct the armature or field circuit so as to secure normal operation.

Before going into winding details, a definition of a "right-" and "left-" hand coil will be given. Consider an armature lying on a flat surface represented by the line *XX* in Fig. 1*A*, with the commutator end of the armature facing the observer and the coil above the shaft or above the line *YY*. Then if the starting and bottom leads for a loop winding or the finishing lead of windings having the wire cut at the end of each coil are on the right-hand side of the observer, the coil is "right-hand." If the leads as above are on the left-hand side of the observer, the coil is "left-hand." The winding shown in Fig. 1*A* has right-hand coils, while the winding in Fig. 2*A* has left-hand coils.

All loop windings put on with the Chapman winding machines have right-hand coils, and wind the coils across the core ends on the inside of the left-hand side of the shaft.

In Fig. 3*A* an armature is shown clamped in the winding jaws of a Chapman winding machine ready to start the first coil. It will be noticed that the armature is turned so that the commutator end is toward the operator, and that the starting lead is brought across the core end to the upper slot. In Fig. 3*B* the first coil is shown wound on the left-hand side of the shaft. Note where and how the starting lead is brought out from the first coil. By turning Fig. 3*B* clockwise 90 deg. we will have a perfect illustration of the definition given above for a right-hand coil.

In Fig. 3*C* the wire has been pulled up and looped over the snubbing pin ready to start the second coil. Note that in Fig. 3*C* the armature has been rotated counter-clockwise to bring the slots for the second coil into proper position. The finish of the second coil is shown in Fig 3*D* with the leads removed from the snubbing pin. This is the condition of the winding shown in the sketches of Figs. 1*A* and 1*B*. In Fig. 1*A* the two coils in place have the four leads marked S_1, F_1, S_2, and F_2. When the coils are laid out flat and the leads brought over to the commutator bars, as in Fig. 1*B*, this shows them to be "right-hand." The full-line arrows in Figs. 1 and 2 indicate the direction of rotation of the winding machine, while the dotted-line arrow shows the direction the armature is rotated in the holder to wind each consecutive coil in its proper order and position.

In Fig. 4 a 12-slot, 12-coil, and 12-bar loop winding is shown with the brushes on the center line of the neutral region. Right-hand coils are wound as shown in Figs. 1 to 3*D* and the leads brought out straight.

In this diagram, Fig. 4, the direction of current flow in the slots is shown by the arrows. The coils marked (*) are short-circuited by the brushes; hence no current flow is shown. In slots *8, 9, 10, 11, 12* and *1* the arrows point away from the center, while in slots *2, 3, 4, 5, 6* and *7* the arrows point towards the center.

With most home-made winding stands and all stands constructed to hold the armature by clamping the shaft and rotated by the left hand, the coils are wound across the outside or right-hand side of the shaft, as shown in Fig. 2*A*. That diagram also shows where and how the starting and finishing leads are located.

By turning the sketch of Fig. 2*A* so that the armature rests on the line *XX*, Fig. 2*B* shows the leads on the left-hand side; hence the coils are "left-hand." In Fig. 2*C* the armature has been rotated counter-clockwise 180 deg., bringing the coils on the inside of the shaft and the leads down or to the left, as shown in Fig. 2*D*. From Figs. 2*A*, *B*, *C*, and *D* it is obvious that by changing the winding from inside the shaft to outside the shaft, or *vice versa*, and with the starting and finishing leads both brought out together, that is, straight out, the coils are changed from "right-hand" to "left-hand" or *vice versa*.

With lap windings in which the leads are brought out in slots one coil pitch apart and the bottom and top leads brought over to commutator bars on the center line of the coil, changing from "right-hand" to "left-hand" coils or *vice versa* will not affect the direction of rotation as will be shown later. On the other

hand in lap windings with the leads brought out straight, as in Figs. 1 to 4, changing from one side to the other of the shaft or changing from "right-" to "left-hand" coils or *vice versa* does reverse the direction of rotation, as will be seen by comparing Figs. 4 and 5. Fig. 5 is the same as Fig. 4 except that the coils are left-hand and the lead throw is to the left. In Fig. 4 the coils are right-hand and the lead throw is to the right.

The slots and bars in Fig. 5 are marked the same as in Fig. 4 and the brush polarity is the same. By comparing the direction of current flow in the slots of Fig. 5, we find that in slots *1, 2, 3, 4, 5*, and *6* the arrows point away from the center and in slots *7, 8, 9, 10, 11*, and *12* the arrows point towards the center. This is just the opposite to Fig. 4, which with the same polarity of the field coils would result in the armature running in the opposite direction. The above shows that changing from left- to right-hand coils or *vice versa*, with the leads connected straight out, will result in reversed armature rotation.

Next, consider the case of lap windings, hand or machine wound, with the leads on the center line of the coil. A study of Figs. 6 and 7, which show right-hand and left-hand coil windings, will prove that changing from right- to left-hand coils or *vice versa* does not affect the direction of rotation. First consider Fig. 6. In slots *2, 3, 4, 5, 6, 7* the arrows point out and in slots *8, 9, 10, 11, 12*, and *1* the arrows point in. Next refer to Fig. 7, which has left-hand coils. In slots *1, 2, 3, 4, 5*, and *6* the arrows point out and in slots *7, 8, 9, 10, 11*, and *12* they point in. The only change is in slots *1* and *7* which are not in an active field; hence the direction of rotation is not affected.

The next step is to consider the effect of reversed rotation on the fields. In the small straight, direct-current, series-type, two-pole motors, we have two methods of connecting the field coils and armature in series with the line. One method is to connect one field coil lead to the line and the other lead to the brush. This puts the armature between the two coils, as shown in Fig. 8*A*. The advantage of this method is that flexible two-conductor cable for line leads can be connected to the field on the opposite side to the brush-holders.

The second method is to make a permanent connection between the two field coils before they are assembled in the frame. One line lead connects to one end of the field; the other field lead connects to one brush-holder, and the other line lead connects to the remaining brush-holder as in Fig. 9*A*. The advantage of this is that when a switch is incorporated in the motor for starting and stopping, the lead *a* from the brush can be permanently connected to one side of the switch and one leg of the line lead or portable cord connected to the other side of the switch.

In Fig. 8*A* the conditions are normal and the arrangement of the coils, armature connections, and current flow will be considered standard for clockwise armature rotation, which is indicated by the curved arrow. The arrow inside the armature circle indicates the direction of current flow from brush to brush, but it does not indicate the direction of current flow in the armature conductors under each pole.

In Fig. 8*B* we have the condition that exists when the coils are changed from right- to left-hand or

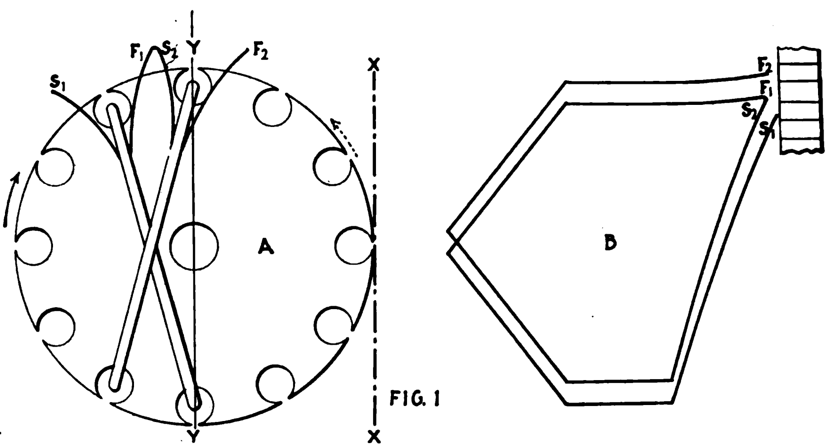

FIG. 1

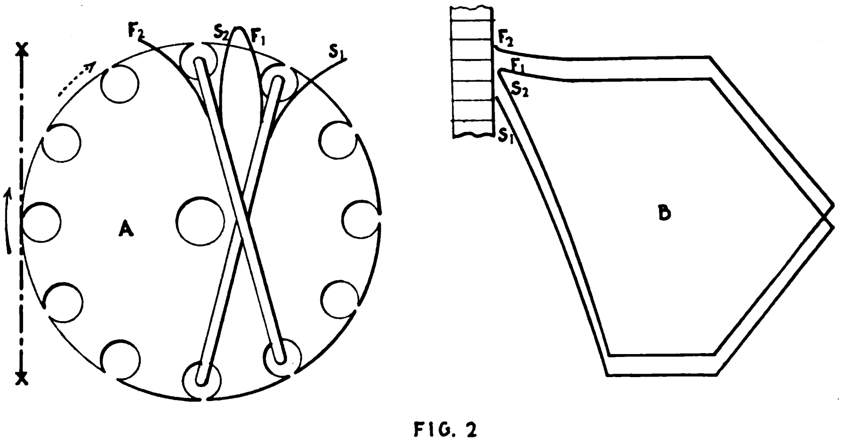

FIG. 2

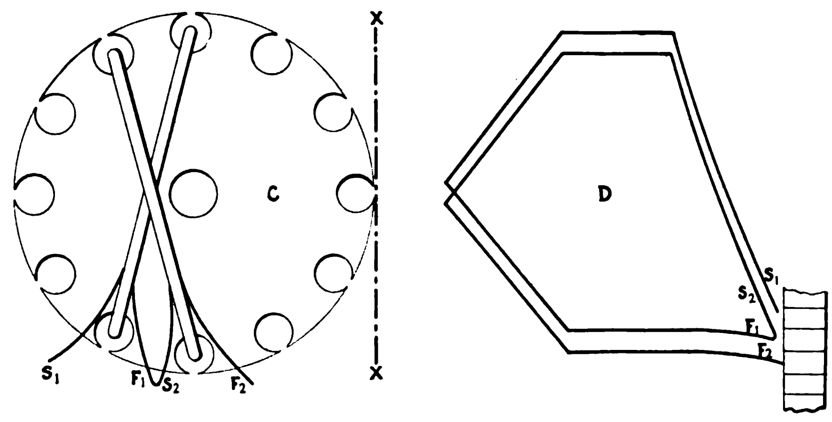

Fig. 1—This is a standard, machine-wound, loop winding on the left-hand side of the shaft, resulting in right-hand coils. This winding is shown again in Fig. 3D.

Fig. 2—Machine winding on right-hand side of shaft, resulting in left-hand coils.

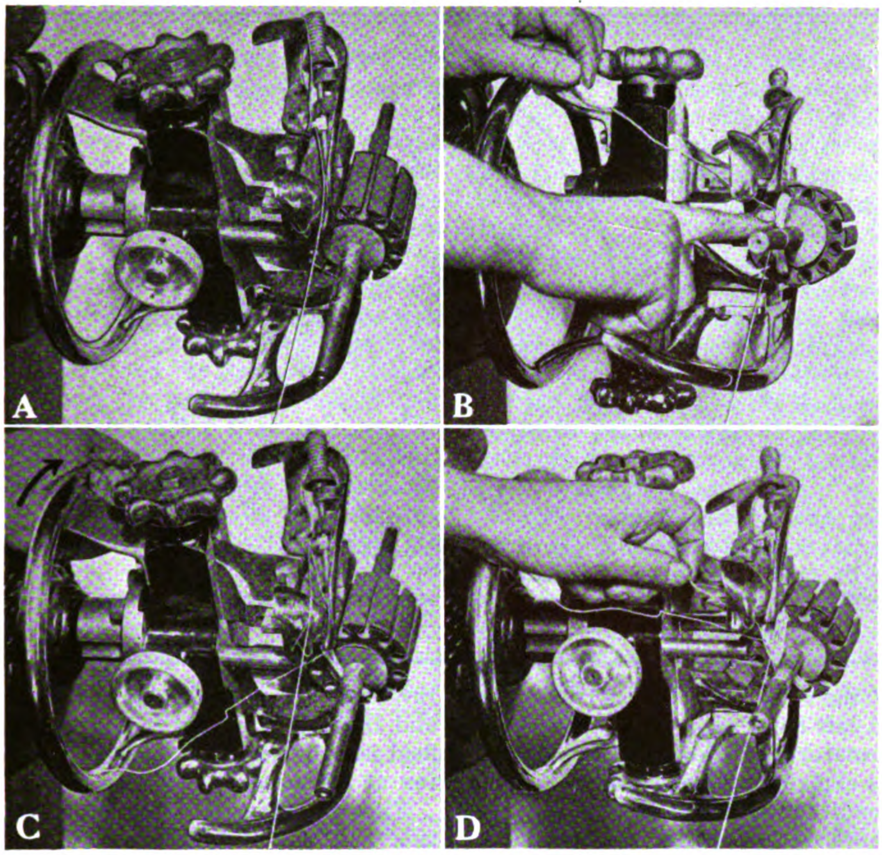

Fig. 3—Four stages in making loop winding with right-hand coils on Chapman winding machine.

A, armature clamped in jaws of machine, ready to start the first coil. *B* shows the first coil of the winding in place. Note how the starting lead is brought out. In *C* the wire has been pulled up and looped over the snubbing pin ready to start the second coil. *D* shows the finish of the second coil and a loop formed by the finish (F_1) of coil *1* and the start (S_2) of the second coil.

vice versa, with leads brought out straight. The current flow through the fields is the same; also the polarity of the brushes remains the same, but the current flow in the armature conductors under the poles has been reversed, as was shown in Figs. 4 and 5. This results in the rotation being reversed, as indicated by the curved arrow in Fig. 8*B*.

With a straight series motor if the reversed rotation can be used, no changes need be made in the field circuit. But if it is necessary to return the rotation back to normal, it can be done by interchanging the field coil leads connected to the brush-holders, as shown in Fig. 8*C*.

Fig. 4—Lap winding with right-hand coils and leads brought out straight at the right. Brushes are on the center line of the neutral region.

Fig. 5—Lap winding with left-hand coils and leads brought out straight at the left. Brushes are on the center line of the neutral region.

This changes the brush polarity and reverses the current flow through the armature, which changes the current flow in the armature conductors under the poles back to normal, and the rotation will be corrected.

The above method is the simplest for this type of motor, as in most cases the leads are attached to the brush-holders by spring clips or screws; hence it is not necessary to unsolder and resolder any joints. The mechanical arrangement of the leads and the space for them will depend upon the make of the motor.

The second method of making permanent connections between two field coils is shown in Fig. 9*A* which indicates conditions for normal operation. Fig. 9*B* indicates the conditions when the current flow in the armature conductors under the poles has been reversed by changing the armature winding from right- to left-hand coils or *vice versa*, with the leads brought out straight.

If the motor can be used with the changed rotation, it will not be necessary to make any changes either in the armature or field circuit. But, if the rotation must be changed to normal, the armature leads will have to be interchanged

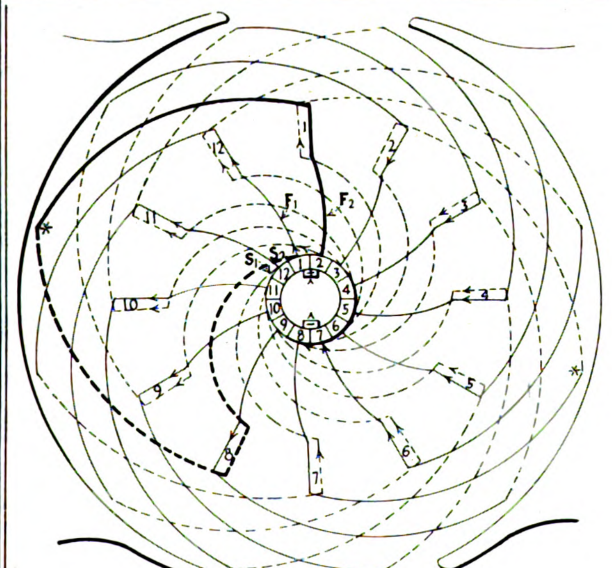

FIG. 4

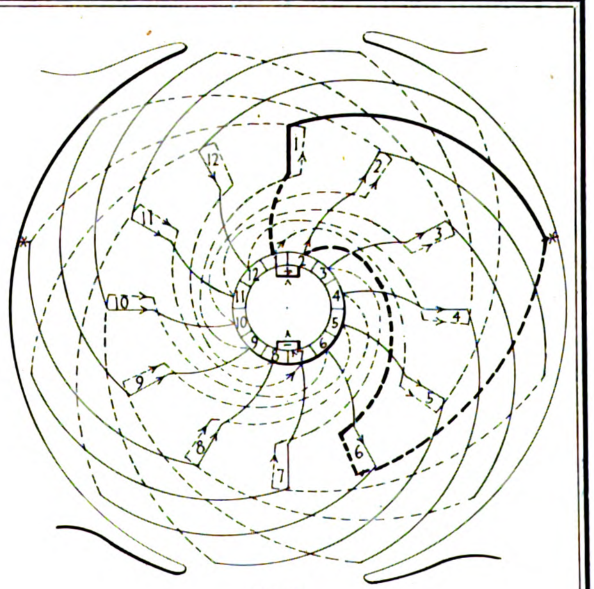

FIG. 5

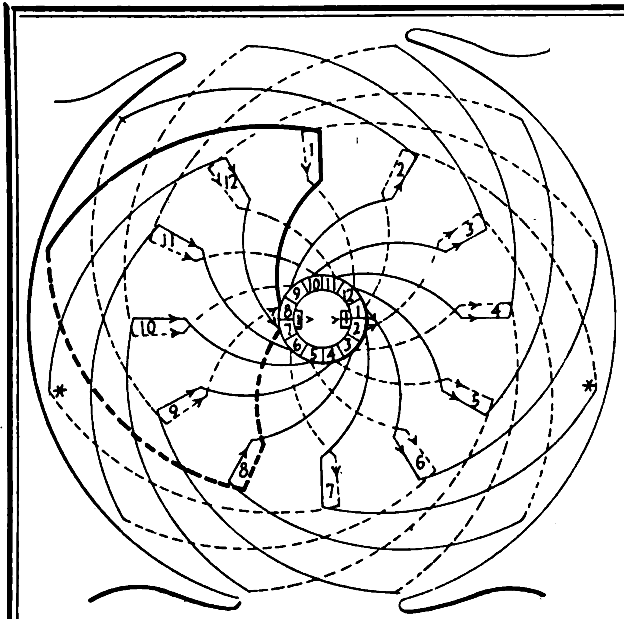
FIG. 6

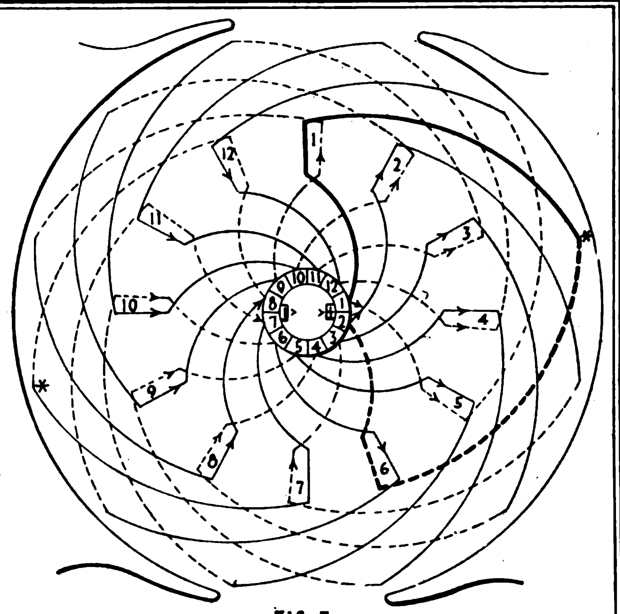
FIG. 7

Fig. 6—Lap winding with right-hand coils and leads on the center line of coils. Brushes are on the center line of the poles.

Fig. 7—Lap winding with left-hand coils and leads on the center line of the coils. Brushes are on the center line of the poles.

as shown in Fig. 9*C*. This will change the brush polarity and return conditions to normal.

We now come to the compensated type of universal series motors. The usual procedure in these motors is to connect the compensating winding on one side of the armature and the main field on the other side, as shown in Fig. 10*A*, which also indicates normal running conditions. Now with armatures in which the coil leads are brought straight out, if the coils are changed from right- to left-hand coils or *vice versa* the armature rotation will be reversed, as explained for Figs. 4 and 5. This condition is shown in Fig. 10*B*. In this case the motor will not operate without sparking and heating and will not deliver its rated horsepower unless either the polarity of the compensating winding is changed or the polarity of the brushes reversed.

The reason for this is that the compensating winding acts against the armature reaction and it must have a fixed polarity with reference to the main field polarity and armature rotation. When the rotation is reversed the polarity of the compensating field must also be reversed, or if the current flow in the armature conductors under the poles is reversed, the rotation is reversed and the action of the compensating field is nullified, which causes sparking at all speeds and loads.

Fig. 10*C* shows how normal rotation and operation are secured by reversing the polarity of the brushes. This is done by interchanging the armature connections. The current flow through the main and com-

Fig. 8—Method of connecting one field coil lead to the line and the other to a brush in a two-pole, series motor.

Fig. 9—Method of making permanent connection between two field coils before being assembled in the motor frame.

Fig. 10—Connections for main and compensating field windings of compensated universal series motors.

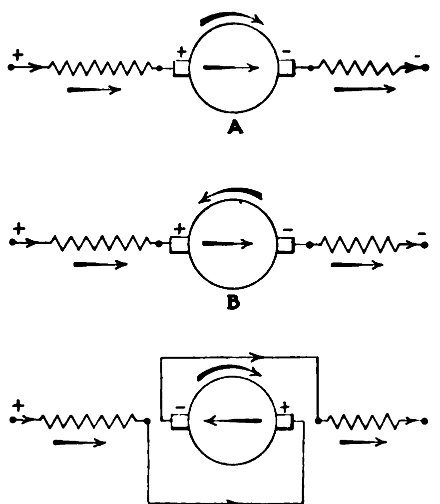

FIG. 8

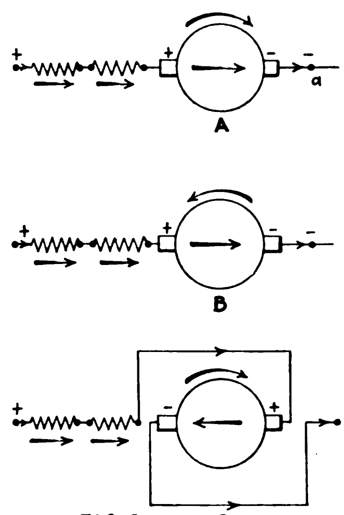

FIG. 9

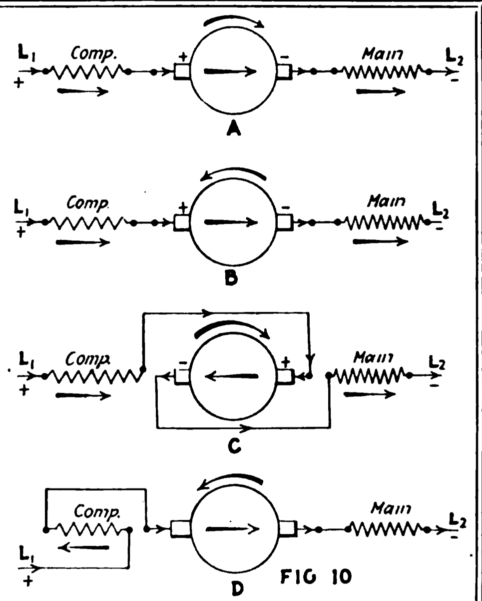

FIG 10

pensating field coils is in the same direction, but the current flow through the armature has been reversed; thus rotation is changed back to normal.

If the reversed rotation of the motor is satisfactory for the application, normal commutation can be secured by interchanging the leads of the compensating field coils, as shown in Fig. 10*D*. This changes the polarity of the compensating field and corrects the relation between it and the armature rotation, and also the main field polarity.

On the smaller sizes of universal-type motors, that is, below ¼ hp., the main field winding is distributed in a number of slots per pole and to obtain a compensating effect the brushes are set permanently off neutral in the direction of rotation. It is obvious, then, that with this type of winding, when the armature rotation is reversed the brushes must be shifted to the opposite side of the neutral line, to an angle equal to the original offset. If the brushes are not shifted, sparking and heating will result. On the other hand, the polarity of the main field or brushes can be reversed, which will return the rotation to normal and eliminate the necessity of shifting the brush rigging.

The above points should be given consideration before changing from right- to left-hand coils or *vice versa* on armatures that have the brushes on the neutral line or shifted off neutral. In these cases the leads are connected out straight or given a throw in the direction of rotation of the armature.

Before making changes the field and brush-holder construction should be studied to determine what effect the change will have on the motor's operation and also how much trouble will be experienced in correcting the effects resulting from reversed armature rotation.

Comments on "Development and Use of Commutator Stones"

I WAS very much interested in the excellent article, "Development and Use of Commutator Stones," reported by Practical Pete in the March issue from a conversation with William L. Weber.

It has been my experience that there is no necessity of having a commutator stone made to fit the approximate curvature of the commutator. An artificial commutator stone will fit itself rapidly to the surface of the commutator and during the wearing-in process every revolution of the commutator changes the face enough so that the stone does not hit the flat spot twice in the same way.

It is true that a commutator stone will cut faster and better after it has worn to a full face, but in ordering the stone with the face already concaved the purchaser has just lost the value of the stone removed in concaving, and I have yet to see the first case where a commutator stone of the proper length has ever made a flat spot deeper during the wearing-in process.

As Mr. Weber points out, it is necessary to have a stone approximately twice as long as the flat spot is wide in order to completely remove it and leave the commutator perfectly round. It is very interesting to occasionally shut down a machine during grinding and note how the flat spot gradually narrows in width, but see how the center of the spot remains just as black as it was originally, showing that it has not been touched.

Just as soon as no blackness remains the grinding is done and not a thousandth of an inch more copper than necessary has been removed—less than the most careful workman can generally do with a turning tool.

Mr. Weber also touched on the glaze on commutators and slip rings. So far as I know there is never any advantage to a glazed surface on a slip ring and it is true that the removal of the glaze from a ring speeds up the acceleration of a slip-ring motor and may cut down the starting time as much as 30 per cent. This is quite important on a.c. elevator motors or other slip-ring motors that are started and stopped frequently.

On direct-current machines, however, this glaze is often necessary for good commutation. It increases the contact drop between the brushes and commutator and in many machines, especially non-interpole machines with varying load, this high contact drop is necessary to reduce the short-circuit currents in the coils undergoing commutation.

E. H. MARTINDALE.

General Manager,
The Martindale Electric Co.,
Cleveland, Ohio.

* * * *

I was much interested in the interview between Practical Pete and W. L. Weber published in the March issue, regarding the uses of commutator stones, and would like to add my views on the subject in the hope that they may benefit others.

I have been using stones of various makes for the past nine years with good results, and by their use considerable time has been saved which otherwise would have been lost in removing the armatures also undercuts the commutator.

The method I use is to start the cutting with a coarse stone, placing it in position on the brush rigging, with the commutator revolving toward the stone, and gradually cut the commutator by letting it swipe the stone until it is even or true. A fine stone is then used to smooth the suface, after which the surface is lightly polished with a sheet of very fine sandpaper. The latter gives the commutator a very high polish and removes all fine burrs. The next procedure, as soon as the machine can be conveniently taken out of service, is to bevel the edges of the bars with a slotting file; this undercuts the commutator at the same time.

For a beginner, a great deal of care is required in truing commutators with stones; otherwise both stone and commutator may be ruined. For instance, if continuous pressure is put on the stone while pressing against an elliptical commutator, the fault, instead of being remedied, is aggravated. It is, therefore, necessary that the stone be used in the same manner as the tool of a lathe is used.

I have also found from experience that too much pressure on the stone is not good, since if the machine being cut is loaded, either motor or generator, considerable flashing at the brushes will result. The brushes will also wear down very quickly. Even when using a high-grade stone, the brushes in some cases, as on an emergency job, have become red hot at the point of contact and blackened the commutator while undergoing the cutting process.

H. E. STAFFORD.

Electrical Engineer,
Provincial Paper Mills, Ltd.,
Port Arthur, Ont., Can.

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

G. A. VAN BRUNT, *Managing Editor*

Can You Rely on Your Spare Parts in an Emergency?

ANYONE who has experienced the shock of learning that spare parts or supplies are unfit for use in time of emergency, does not have to be told that it is unpleasant, to say the least. The fact that spare parts such as armatures or rotors, coils, belts and the like are kept in stock for emergency service is ample proof that they are rightly considered to be very important.

However, when spare coils, for example, are found to be of the wrong size, or with the insulation rotted, or otherwise defective, there is plain evidence of carelessness on the part of somebody. So many things can happen to parts in stock that only careful storage and handling and frequent inspection will defeat some of the unsuspected enemies, such as rodents, dust, fumes, extreme changes of temperature, and so on, that cause stored material to deteriorate rapidly.

Then again, there is always the possibility of spare parts being ordered for the wrong type of machine, particularly when these have been purchased second-hand, or altered in any way.

A great deal of unnecessary trouble can be saved by taking care to store spare parts in a clean, dry place that is free from corrosive fumes, checking up and testing all material carefully before it is placed in stock, and inspecting it frequently thereafter. By so doing not only will the cost of wasted material be saved, but service delays and very costly and unpleasant situations will be avoided.

Will the Oil-Electric Locomotive Reduce Cost of Steel Mill Yard Switching?

IN VIEW of the recent developments in the oil-electric locomotive, this form of motive power should be of particular interest to industries having considerable yard switching such as is the case in the steel mills.

Recent tests made by the Central Railroad of New Jersey in one of its terminal yards resulted in an average fuel cost for the oil-electric locomotive of $1.16 per 1,000 tons of freight handled, while the fuel cost of a steam locomotive operating under the same conditions over an equal period of time was $6.92 per 1,000 tons of freight handled. Fuel costs are only one of the several economies that are expected to be obtained with the oil-electric locomotive. Use of it will eliminate coaling stations, ashpits, and turntables and is expected to do away with expensive round houses and hostling services. The maintenance cost of the oil-electric locomotive is said to be much below that of the steam locomotive; this means that in addition to the saving in money, due to decreased maintenance, the oil-electric locomotive will spend more time in service, and less in the round house.

For some time the steel mills have been very much interested in reducing their yard switching costs. Electric locomotives supplied from overhead trolleys have been proposed, but discarded as impractical, due to the necessity of having overhead space clear for yard jib cranes, traveling cranes, locomotive cranes, and the like. Third rail locomotives have been seriously considered, but due to the large number of tracks located in a congested area, the trackage and switching becomes very complicated. One steel plant, in the endeavor to reduce its yard switching costs, has installed a large, storage-battery locomotive. The outcome of this installation will be awaited with interest.

The oil-electric locomotive appears to be an ideal solution of the steel mill yard switching problem. It goes without saying that the test results of these locomotives obtained by the various railroads will be watched closely by steel mill operating engineers who are alive to possible cost reductions that may be thereby obtained.

Selecting the Best Method is an Important Part of Any Job

NEED, on the part of industrial operating executives, for quick thinking and ingenuity in meeting unusual conditions was brought out some time ago by an incident that is not without a humorous aspect.

In a certain plant a large water tank is mounted on a supporting structure above the main office. During severe cold weather one winter a huge icicle formed on the tank and when it eventually broke loose it crashed through the roof of the office, causing a good deal of damage.

The following year another icicle formed and had grown to dangerous size before it was noticed. The office employees refused to stay at their desks and in the absence of the Master Mechanic there was a hurried consultation to decide the best way of removing the icicle before it broke loose. The weather was extremely cold and no one wanted the job of climbing up and knocking the icicle down, as it was in reality a dangerous undertaking.

Before action was taken the Master Mechanic returned and took in the situation at once. He slipped out of the office and within a short time had solved the problem cheaply and simply by shattering the icicle with a rifle bullet. That may not always be the best way of getting rid of icicles, but in this instance it served the purpose well.

Speed in undertaking a job is oftentimes highly desirable, but the method that first comes to mind is not always the best one. In the long run, time can often be saved by studying the situation with sufficient care to make sure that the methods used are the simplest and most efficient, all things considered.

Be Sure That Your Money-Saving Ideas Will Really Save Money

NOT LONG ago we heard of a money-saving idea that wins the prize for misdirected effort towards economy in plant operation.

A well-known steel plant has a number of large motors and several turbo-generators, which are supplied with air that is passed through air washers for cooling and cleaning. It costs money to pump water at this plant and the management decided that a considerable saving could be made by shutting down these air washers during the winter months when cooling of the air was not required. This was done and a saving was made, but unfortunately this saving was lost the next summer, due to an insulation failure on one of the large motors. This failure was traced to dirt in the armature of the motor and the logical reason for dirt getting in there, was because the air washer did not have an opportunity to remove the dirt before it reached the motor. Rewinding of the armature was required—a job that was done very expeditiously in five days. Meanwhile the entire mill was shut down and the cost of this delay in production, added to the rewinding cost of several thousand dollars, swallowed up many, many times the small saving in water cost.

Air washers are installed primarily to clean the air and the fact that they cool the air at the same time is only a secondary consideration. Knowledge of, or consideration of, this simple fact would have saved a large amount of money and a great deal of trouble.

A careful investigation should be made of all angles of a money-saving idea before it is put into operation. There is a reason for the use of most plant equipment and elimination or shutting down of part of it should be done only after careful consideration of the possible consequences.

Improper Application of Equipment May Cost More Than You Realize

EVERY operating engineer knows from experience that it is not difficult to find many instances of failure to secure maximum output or service from some installation, due to faulty application of one or more component pieces of equipment. A case in point came to light recently in an industrial plant which makes use of a special and costly machine for performing certain operations on four different sizes of metal stock. Naturally, the operations on the heavier stock must be performed at slower speeds than in the case of the lighter stock.

Through ignorance or carelessness, when this machine was originally installed a constant-speed drive was selected. This meant that the machine speed had to be limited to the value that was suitable for handling the heaviest stock, whereas light stock was handled a large part of the time.

At length, someone who had a wider knowledge of the results that can be accomplished by proper selection of motor and control equipment, suggested that a variable-speed motor and suitable control be used on this machine. The change was made and production has increased considerably, as each weight of stock can now be handled at the maximum suitable speed.

In many cases the selection of the control equipment should receive more attention than it now gets. Control engineering has made so many advances during the past few years that it is safe to say that many engineers do not fully realize the results that can be accomplished, and the possibilities that are offered, by well-designed control equipment.

The next time you have occasion to select control equipment, investigate thoroughly the designs available and make friends with a few good engineer salesmen of this equipment. You may learn some things that will surprise you, and that you can use to good advantage.

Take a Day Off and Visit Your Neighbor's Plant

THERE is nothing like the word-of-mouth method for passing on helpful experiences. One way of obtaining this contact is through association meetings or conventions; however, these meetings are too infrequent and quite often degenerate into good-fellow parties rather than into exchanges of experiences in solving operating problems.

Seemingly it is hard for some to realize that their neighbor's plant is confronted with problems very similar to their own. Of course, it is quite common to look over another man's plant when deciding upon what kind and type of new equipment should be obtained. But the visits should be made oftener and with the view of obtaining operating information and ideas as well as the foregoing. Also, visits should be made to a greater variety of industrial plants than would be true if new equipment only were to be inspected. If your neighbor manufactures the same product that you do, it is quite likely that he will look at his problems in the same manner that you do. On the other hand, the operating man in another kind of industry may attack the same problem from an entirely different angle.

The International Harvester Company is one organization that recognizes this fact, and encourages visits between men in its various plants. In fact, this company goes so far as to organize regular trips on which even the foremen from one plant will visit those of another. For example, those engaged in making tractors may visit a rolling mill; those that make trucks may visit the harvester plants, and so on.

After all, doing something better than it was done before is simply the fruition of an idea. Ideas do not come out of thin air; they come from experiences, things we have seen, and our imagination. Give these forces a chance to develop by talking things over with your neighbor during a visit at his plant. Both he and you will benefit thereby.

Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Practical Pete

Who Can Answer These?

Method of Checking Bearing Alignment.—I should like to know how to check the alignment of bearings on machines having three or more bearings supporting the same shaft, or where two shafts are coupled together by means of rigid couplings. An example of this is a three-bearing, motor-generator set or a large, heavy-duty motor or pump having a pedestal bearing in addition to two regular bearings. I shall appreciate any suggestions that readers can give me for doing this work.
Chicago, Ill. F. B.

* * * *

Can Slip Ring Motors Be Started by a Compensator?—I have several three-phase, 440-volt, wound-rotor, induction motors ranging in size from 25 to 150 hp. I have several spare compensators which I would like to use for emergency starting of these motors in case anything goes wrong with the present drum controller and secondary-resistance type of control. My plan is to short the slip rings and start the motors with a compensator just as though they were squirrel-cage induction motors. Is this practicable? Is there any danger of damaging the motors? I would like to know the experience of other readers in this regard.
Chicago, Ill. W. J. A.

* * * *

Where Should I Use This Kind of Wire?—Most manufacturers of wire for use in house wiring and in industrial plants make three kinds of wire: a Code wire, an intermediate grade and a 30 per cent rubber compound grade. I should like to learn from other readers whether they use all three grades around their plants and if so, the basis on which they decide the grade that shall be used for a certain application. Do you find any of these grades unsuited for industrial plant use? I shall appreciate any information that you can give me regarding the proper application of these three grades of wire.
Newark, N. J. B. S.

* * * *

Tests on Motors Do Not Check Nameplate Data—We have three 200-hp., 600 r.p.m., 60-cycle, three-phase, 440-volt, wound-rotor, induction motors, that are used to drive tube mills in our cement plant. According to the nameplate, the full-load, primary current is 245 amp., while the full-load secondary current is 346 amp. On making a test on one of the motors, I found that with the belt off the primary current was 125 amp. Upon putting the belt back on the pulley and loading the motor, the primary current rose to 275 amp., while the secondary current went up to 150 amp. Upon increasing the load, the primary current reached 350 amp. and the secondary current 275 amp. According to the nameplate the primary current should be less than the secondary current, while the tests show just the opposite. The temperature rise on the motors so far has stayed below 40 deg. Can some reader tell me what is the matter with these motors?
Ragland, Ala. R. I. F.

* * * *

Changing Speed of Induction Motor.—What will be the horsepower and power factor of a 3-hp., Fairbanks-Morse, 1,200-r.p.m., 6-pole, 54-slot, standard factory wound, 60-cycle, 440-volt induction motor, wound with No. 16 wire in 54 coils with 28 turns per coil, span 1-9, when this winding is regrouped for eight poles instead of six?
Portland, Ore. P. M. W.

* * * *

What is Function of Reactive Volt-Ampere Indicator?—We recently ordered from a meter manufacturer a three-phase, switchboard-type wattmeter. When the meter arrived at the plant it was marked, reactive volt-ampere indicator, instead of wattmeter. I wish some of the readers of this column would explain the difference between these two meters and tell me the application and use of the reactive volt-ampere meter. Any details regarding the use of this meter will be very helpful.
Detroit, Mich. R. J. B.

* * * *

Trouble in Keeping Commutator Bars Straight.—I have considerable trouble in keeping commutator bars true and straight when the commutator is put back on the shaft of the armature after being repaired. The type of armature that I have particular trouble with is a ½-hp., d.c., No. A3, Westinghouse motor. The commutator is held in place by the front and rear V-rings which are locked in place by means of a plate screwed onto the armature shaft. In tightening this plate the armature bars move at an angle or become skewed. Can some reader tell me how to assemble these small commutators in such manner as to prevent them from skewing?
New York, N. Y. B. L. A.

* * * *

What Causes Heating of This Cable Box?—There are six 1,000,000-circ. mil cables connected in parallel per phase on the cable run between our 2,000-kw. 3,000-amp., 480-volt turbo-generator and the oil switch. These cables are grouped in six conduits, each of which holds one cable from each phase, or a total of three cables. The conduits terminate in the bottom of a sheet-iron distribution box. In this box the cables are regrouped so that all of the cables from one phase go out of the left-hand side of the top of the box; all the cables for another phase go out through the center of the top of the box; and the six cables for the remaining phase go out through the right-hand side of the top of the box. With this arrangement the entire top half of the sheet-iron distribution box heats up. What causes this heating and how may it be overcome? Should I make the box of fiber instead of sheet iron.
Bellingham, Wash. E. M. D.

Answers Received To Questions Asked

What Is the Best Type of Drive for This Installation?—I should like to have the advice of readers on the following problem. We wish to operate by a 10-hp., 1,150-r.p.m. motor, a small machine shop and a small reciprocating pump, which are in different rooms, separated by an 8-in. brick wall. We wish to place the motor in the room with the pump. There are three possible drives. (1) Mount the motor on the floor or wall and use a short, overhead lineshaft with three pulleys, one for the motor belt, one for driving the pump and the other for driving the machine shop. (2) Mount the motor on the ceiling and connect it directly to a short lineshaft with two pulleys, one for the pump and one for the machine shop. (3) Mount the motor on the floor and drive the pump directly through a speed reducer. In this case I would use between the motor and the speed reducer a short piece of shaft on which would be mounted a pulley driving an overhead shaft, which in turn would be belted to the machine shop lineshaft. Will someone please tell me which of these combinations would be best from the standpoints of cost, maintenance and operating advantages? Do you know of a better type of drive than I have outlined?
Chicago, Ill. O. H. E.

In reply to the questions asked by O. H. E., I advise using method No. 1, with the motor suspended from the ceiling. This will allow a horizontal belt drive from the motor to the short lineshaft and will not require as tight a belt, as would be the case if the motor were mounted on the wall or floor.

It is not advisable to connect the motor directly to the pump shaft. In this case speed reducers would have to be used. These are expensive. Also, the use of flexible couplings should be avoided, if possible.
Watertown, Mass. F. B. WILLIAMS.

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The second drive as outlined by O. H. E. will be the best to use as it does away with some of the belting which would be necessary in the first case. The third method would be more expensive. Furthermore, connecting the shaft extension to a speed reducer and running a belt from it, is not, in my opinion, very good operating practice.

Two modifications of the second plan are suggested. When a motor is mounted on the ceiling there is not always enough headroom to permit con-

venient oiling and cleaning of the motor. A platform on which the motor might be mounted could be built and suspended from the ceiling. This method of installation would keep the motor and one belt away from the floor and out of the way.

Another plan would be to purchase a motor with a shaft extension on each end, and two pulleys. This would do away with the countershaft, as the pump and machine shop could be belted directly to the motor shaft. The motor could be mounted either on the ceiling or on a suspended platform, as suggested above. If a new motor is being purchased, one with a special shaft extension may be obtained in a few weeks time, at slight extra cost.

Boston, Mass. L. B. MORRILL.

* * * *

Replying to the question by O. H. E., the first type of drive he mentions appears to be the best from the standpoint of maintenance and construction. In view of the fact that motors are generally given very little attention on small installations, I would advise against placing them on the ceiling. Motors mounted in this position are very difficult to repair or clean. They are much easier to maintain if they are mounted on the floor or on wall platforms. In the latter case the wall platforms should be rigid enough to resist all vibration, and large enough for a man to stand on either side of the motor.

The floor is an excellent place to mount a motor, but usually floor space is limited, while plenty of wall space is usually available. On page 597 of the December issue O. H. E. will find a neat little motor stand which may be built cheaply in almost any shop. The only disadvantage is that the platform looks to be rather small and the oiler would have a difficult task in determining whether the bearings were well oiled, unless he carried a ladder with him to place on either side of the motor. It is not good practice to use portable ladders and they should be discarded and replaced with permanent ones, where required. Safety first always pays.

Chief Electrician, LEE F. DANN.
Donnacona Paper Co., Ltd.,
Donnacona, Que., Can.

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Referring to O. H. E.'s question, the first drive that he suggests is the best. Locating the motor on the floor or on a wall bracket and belting to a lineshaft and then to the pump and machine shop, will allow the installation to be made of standard material, that can be readily procured and replaced, at low cost in case a breakdown should occur.

The objection to the second alternative, mounting the motor on the ceiling and connecting it directly to the lineshaft, is primarily a question of the motor speed. The motor speed of 1,150 r.p.m. would be too fast for the ordinary lineshaft bearings and would probably give unsatisfactory pulley ratios for driving the pump and machine shop. In this case the lineshaft pulleys would be prohibitively small, or the driven pulleys unreasonably large. A less vital matter would be the relative inaccessibility of the motor for oiling, minor repairs, and other maintenance.

Using a speed reducer between the motor and pump shaft, as suggested under method No. 3, is objectionable because of the cost. Speed reducers are well built, but are more expensive, in comparison with ordinary lineshaft material. For satisfactory operation there should be flexible couplings on both sides of the speed reducer, between the motor and the pump, which would increase the cost of the power drive still further.

No. 1 type of drive will be the most satisfactory if the space available and the speed ratios will permit its use. A properly arranged drive using leather belts of ample width and thickness will be more efficient and cause less operating trouble than any other type of drive. If an accident occurs to any part of the driven machinery, about all that can happen is that the belt will slip off, without breaking chains, tearing teeth out of gears, or otherwise damaging the transmission machinery.

Plant Engineer, H. D. FISHER.
New Haven Pulp & Board Co.,
New Haven, Conn.

* * * *

Referring to O. H. E.'s problem, a little more information, such as the following questions suggest, would help in deciding which arrangement is the most efficient. Is the machine shop load constant? Is the shop operated intermittently or continuously when the pump is operating? Does the pump operate continuously or intermittently, and at what speed? Is the motor a.c. or d.c.? Are clutches to be used for disengaging units for no-load starting of the drive?

Arrangement No. 1 is the cheapest, most practical, and represents the most common practice. Clutches may be used on each side of the main drive pulley on the line or jackshaft to throw off the machine shop load as required, or in case of accident. The pump can similarly be thrown in or out of service as occasion demands, and the starting of the motor facilitated by disengaging the clutch.

Drive No. 2 has the disadvantage that the jackshaft speed would be too high, unless a special ball or roller bearing construction were used. Also aligning the motor with a shaft would require four bearings in line, which is objectionable unless a flexible coupling were used between the motor and jackshaft. Altogether, this arrangement is not very flexible and practical, considering individual operation and starting.

Drive No. 3 is the most expensive, as several flexible couplings would be required if the speed reducer were mounted between the motor and pump. This arrangement is not very flexible, and like arrangement No. 2 would require a higher grade of maintenance service.

Engineering Dept., E. H. LAABS.
Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

Is This Lamp Consumption Too High?—Our plant is a malleable iron foundry and our lights are operated from 230-volt direct-current power supply. During the first 314 days of this year, we used a total of 972 lamps in 847 outlets, making an average consumption of 1.33 lamps per outlet per year. To be specific, we used 230, 100-watt type C lamps in 275 outlets, or 0.97 lamps per outlet per year. We used 162, 200-watt type C lamps in 160 outlets, or 1.18 lamps per outlet per year. For portables and extensions at molders' benches we used 600, 50-watt, mill-type lamps in 412 outlets, or 1.7 lamps per outlet per year. The large lamps are subjected to slight vibration due to machinery and lineshafting. The lamps burn 9½ to 10 hr. per day. I should like to know whether other readers think that our average lamp consumption is too high. Also I shall appreciate any information regarding lamp consumption in plants having conditions similar to a foundry, as well as in other types of manufacturing plants.

Chicago, Ill. W. A. B.

Replying to W. A. B.'s question, the number of lamps required during daylight hours depends entirely on the amount of natural illumination available. If the windows are small or dirty more lamps will be required than would otherwise be the case. Natural illumination may be accurately measured with a foot-candle meter.

For a foundry the intensity of light in foot-candles should be as follows: On the charging, tumbling, cleaning, pouring and shaking-out floors, 2 to 4 foot-candles, where rough molding and core making are done, 3 to 6, and for fine molding and core making 5 to 10 foot-candles.

The lighting arrangement for a certain foundry approximately 80 ft. by 200 ft., or a total area of 17,600 sq. ft., is: 300-watt Mazda lamps in RLM standard dome reflectors, spaced 30 ft. by 40 ft. and hung 35 ft. above the floor. This hanging height permitted the use of bare lamps, but with an increased height the spacing could naturally be increased. The average intensity of illumination is 5 foot-candles.

These lamps are lighted only on dark days, in the first part of the morning or in late afternoon. They were not used between the hours of 10 a. m. and 2 p. m. more than five or six times last year.

Boston, Mass. F. B. WILLIAMS.

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In answer to W. A. B., I would say that he is to be congratulated, because foundry service is very hard on electric lamps. Owing to the accumulation of dirt, lamps have to be cleaned frequently, which increases the liability of breakage. Also, the use of portable lamps and extension cords tends to shorten the life of the lamps, which is likewise true to a less extent for fixtures subjected to vibration. Based on an average of 9.75 hr. per day for 314 days the lamps were burned 3,061 hr., which is a trifle over three times the rated life of the lamps.

According to the actual rated life of these lamps, the total consumption would have been 2,970 lamps in comparison to the 972 that were used. However, this comparison is too good to be true for the modern lamp, which is rated for 1,000 hr., but is considered all right to use until broken. After 1,500 hr. the output decreases to such

an extent that it produces only about 90 per cent of its rated lumens. Iron and steel plant applications are comparable to foundry lighting and in fact include it. In such a plant having 3,865 outlets, there have been as many as 12,300 lamps charged out in one year. This large consumption of lamps has been reduced recently by good management and improved lamp design.

If it were possible, it might be said that W. A. B. was not using enough lamps per year. Money invested in illumination produces a greater return than any other similar sum spent on plant equipment. A dollar now buys 16 times the illumination that it did 35 years ago. During the past decade the increased return on the investment has been about 62 per cent.

Electrical Engineer, D. W. BLAKESLEE.
Jones & Laughlin Steel Corp.,
Pittsburgh, Pa.

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Cleaning Wire-Mesh Carbon Brushes—What is the best way of cleaning wire-mesh, carbon brushes that are heavily coated with carbon dust and dirt? Scraping with a knife is slow and not entirely satisfactory. Is there some solution that could be used to clean them? These brushes are used on an old plating generator that is subjected to frequent overloads and the commutator is slightly grooved; so there is considerable sparking. The commutator has been turned down about as much as it can be and as the generator will be replaced before long we do not want to put on a new commutator. However, I must keep the generator in as good condition as possible until it is replaced.
Milwaukee, Wis. A. J. K.

In answer to the question asked by A. J. K., relative to the method of cleaning wire-mesh carbon brushes, I have found it very satisfactory to put the brushes in a copper plating solution and electroplate them until they look like new. The brushes are thus cleaned off while undergoing the plating in the plating bath. I have used this method quite a number of times and have found it entirely satisfactory.

Chief Electrician, HARRY J. ACHEE.
City of Woodward,
Woodward, Okla.

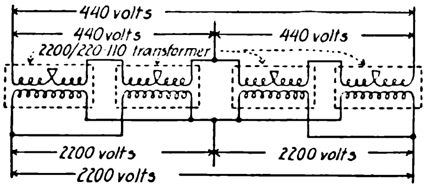
* * * *

I would suggest that A. J. K. use gasoline to scrub the brushes, with which he is having trouble. A steel bristle brush will clean the pores of the brushes especially near the surface. After the gasoline has dried off, soak them for about 30 min. in a solution composed of two parts of water to one part of ammonia. Then remove them from the solution and put them in clean water, rinsing them thoroughly. If this does not remove all of the grease, the solution can be made stronger. It is well to wear rubber gloves when handling the brushes in this ammonia solution, because the strong solution injures the hands to a certain extent, especially if there are cuts or bruises on one's hands.

I have also used sulphuric acid for cleaning copper brushes and this method could be easily used around a plating establishment, such as is the case with A. J. K. The proper way to proceed with this method is to first dip the brushes in a hot potash solution and then rinse them in clear water. The brushes may then be dipped in sulphuric acid until all grease is removed. There is a danger, however, in using this method in that the acid might not be entirely removed from the brushes and when the brushes are put on the commutator they might injure its insulation. Special pains should be taken to remove all of the acid from the brushes. GRADY H. EMERSON.
Birmingham, Ala.

* * * *

What Is the Capacity of this Transformer Bank?—I have four 25-kva., 2,200/220/110-volt transformers connected to a three-phase, 2,200-volt, power supply as is shown in the accompanying diagram. The secondary of each transformer is so connected that the two 110-volt windings are in series to supply 220 volts. As can be seen from the diagram, 440-volt, three-phase power is obtained from the secondary of this bank of



transformers. I shall greatly appreciate it if some reader will tell me what the capacity of this bank of transformers is with the connection that I am using. I should also like to know the safe secondary line current and also the safe primary line current that these transformers will take with this connection.
Hattiesburg, Miss. J. M. M.

Answering J. M. M.'s question, the connection he is using is open delta. The bank of four 25-kva. transformers operated on this connection has a capacity of 86.6 kva. The full-load, high-tension current at 2,200 volts is 22.75 amp. and the corresponding low-tension current at 440 volts is 113.7 amp. These values do not take into consideration the small losses that occur in the transformers, but are close enough for loading up the bank.

Morgan Hill, Calif. I. J. GRONWOLD.

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Referring to the query of J. M. M., concerning the connection of four 25-kva. transformers, I would say that the arrangement he shows is practically equivalent to an open-delta connection with the primaries two in parallel and the secondaries two in series. In other words, another set of two transformers similarly connected across the third phase would give a balanced delta connection.

The regulation and efficiency of the open-delta connection are poor, since one phase of the load receives power from two sets of two transformers in series.

It is customary to use the open-delta connection for installations that will grow, to save in first cost. When the load demand increases, the delta is closed by the addition of a third transformer, or set of transformers.

The total capacity of the transformers in an open-delta connection should be 15 per cent greater than the load. This means that the load on an open-delta connected bank of transformers should not exceed 87 per cent of their rating.

Since all coils are in use in the four transformers in this bank, the capacity available is 87 per cent of 100 kva. or 87 kva. Neglecting exciting current, the full-load primary current is equal to $(87 \times 1{,}000) \div (2{,}200 \times 1.73) = 23$ amp., and the full-load secondary current $= (87 \times 1{,}000) \div (440 \times 1.73) = 114$ amp. These calculations are based on the formula, $\text{Kva.} = (E \times I \times 1.73) \div 1{,}000$, and $I = (\text{kva.} \times 1{,}000) \div (E \times 1.73)$, in which E=volts, I=amperes, and kva.=kilovolt-amperes.

FREDERICK KRUG.
Supt. of Power Production,
Porto Rico R. R., Light and Power Co.,
San Juan, Porto Rico.

* * * *

In answer to the question asked by J. M. M. regarding the safe current loads in primary and secondary of a 100-kva. transformer bank, I would say that the connection scheme shown in the diagram is the familiar open-delta connection and is good for a load of approximately 58 per cent of the load that can be carried on a closed-delta connection employing the additional transformer or, in this case, two transformers. The kva. load capacity in the foregoing case is 87 kva. Safe primary current at 2,200 volts will be 22.5 amp. and safe secondary current 113.5 amp. If he has any facilities for cooling the transformers, such as a cold air draft or cold water sprayed on the cases, the load can safely be increased 25 or 30 per cent provided the oil is in good condition.

Chief Electrician, LEE F. DANN.
Donnacona Paper Co., Ltd.,
Donnacona, Que., Can.

* * * *

In reply to J. M. M., I would say that his diagram shows a bank of transformers with both primary and secondary sides connected open delta or V. The capacity of this bank will be approximately 87 kva., as may be seen from the following analysis.

Let I=the maximum phase current; then the corresponding line current with a delta connection will be equal to $1.73 \times I$. However, with an open-delta connection the line current will be equal to I; that is, the line current will equal the phase current. Therefore, the output of an open-delta connection as compared to a closed-delta connection will be in the ratio of I to $1.73 \times I$ or 1 to 1.73. In other words the capacity of an open-delta connected bank will be 58 per cent of the closed-delta connection or 87 per cent of the rated capacity of the two transformers used in the open-delta connection. Inasmuch as the primaries of two transformers are connected in parallel to make one leg of the open-delta connection, we may consider each leg as having 50 kva. transformer load connected thereto. Then 87 per cent of $(50+50) = 87$ kva.

The current loads will be equal when the three-phase load is balanced. The safe primary current will be about 22.5 amp. per terminal or twice the current rating of one transformer, if the nameplate indicates primary amperes. The safe secondary current will be about 113.5 amp., which is approximately the

ampere rating of one transformer when connected for 220 volts. A system of this kind should only be used temporarily, because of the low efficiency and poor power factor of this connection. ALEXANDER MCLENNAN.
Westinghouse Elec. & Mfg. Co.,
Pittsburgh, Pa.

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At a normal high-tension rating of 2,200 volts, a primary current of 11.4 amp. will be taken by each 25-kva. transformer; the secondary current delivered by each pair of transformers at 440 volts would be approximately 114 amp.

Addition of two more transformers similarly connected would form a closed delta connection and give the bank a rating of 150 kva. In this case, with a line potential of 2,200 volts, the line current will be 39.5 amp. and the phase current or the current in the high-tension winding of each transformer will be 22.8 amp. However, as now connected (open delta), the line current and the phase current are the same and the capacity of the bank is limited to 22.8 amp. on the primary side, with a line current of 114 amp. on the 440-volt secondary.
West Allis, Wis. EDWARD JAMES.

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The diagram of connections given by J. M. M. shows what may be considered to be two 50-kva. transformers connected in V or open-delta. Since the full line current must flow through each transformer the capacity of the total bank for safe normal load operation will be only 86.6 per cent of the actual capacity or 86.6 kva.

The normal safe line current will be as follows: 2,200-volt side, 22.7 amp.; 440-volt side, 113.5 amp. These values do not include any allowance on the 2,200-volt side for core loss current which will increase the figure of 22.7 amp., to 23.5 or 24 amp. for commercial transformers.

Care should be used when connecting the 2,200-volt windings to see that all the voltage connections are the same and that no taps are used, which might give either a higher or lower voltage value. C. OTTO VON DANNENBERG.
Designing Engineer,
Sanderson & Porter,
Springdale, Pa.

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In answer to the question asked by J. M. M., I wish to submit the following: The connection shown is an open-delta connection, and will deliver 86.6 per cent of the nameplate rating of the transformers in the open delta connection or 57.7 per cent of the power that would be delivered from a closed delta connection having six 25-kva. transformers connected two in parallel. The closed delta capacity would be 6×25 kva.=150 kva. The open-delta capacity is 150×57.7 per cent=86.6 kva. The nameplate rating of each transformer is 25 kva. which multiplied by 86.6 per cent gives us 86.6 kva.

The current in a three-phase system =(kva.$\times$1,000)$\div$(line voltage$\times$1.732). In this case the full-load primary current=(86.6$\times$1,000)$\div$(2,200$\times$1,732) =22.7 amp.

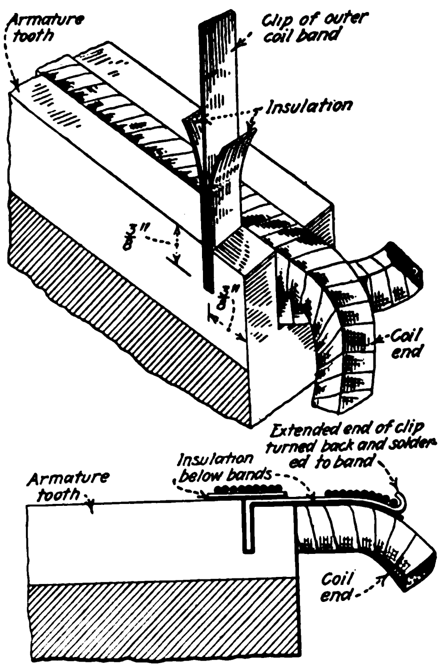
As the secondary voltage is one-fifth of the primary voltage, the secondary current must be five times the primary current; that is, 113.5 amp.

As the efficiency of a transformer is never 100 per cent, the secondary current will be somewhat less than 113.5 amp. These values are safe.
Ustick, Idaho. ALEX BREMNER, JR.

* * * *

Armature Bands Overheat.—Five bands are used on a 220-volt, d. c. armature with which we are having trouble. The armature coils slope very sharply and to prevent the outside bands from slipping off the ends of the armature, the winder soldered copper strips across the bands so as to tie them together. Six 3/8-in. strips were placed parallel to the coils and spaced at equal distances around the armature. The bands as well as the copper strips are well insulated from the armature winding, but the bands and particularly the copper strips become very hot, presumably from some induced current. I would like to know what causes this heating and how it may be prevented. If it is induced current that causes the heating please explain what causes this current. Is there any way in which I can tie these bands together that will not cause the heating referred to?
Oelwein, Ia. L. T. M.

In reply to the question of L. T. M., I am positive that his trouble is due to induced currents in the band connections; he has a squirrel-cage effect from the method of banding that he is using. I have found good results from the following method of fastening end bands so as to prevent them from slipping off the coils, in cases where the coil ends slant to a considerable extent.



Method of anchoring end bands that are inclined to slip off end of armature.

In a tooth, a slot is cut wide enough to take the thickness of the clip and a thickness of insulation on each side of it, as shown in the top illustration. Insulation for the bands is then put on in the regular manner and the clips bent over the insulation, the bands run on, and soldered to the clips, as shown in the bottom illustration.

After removing the bands from the coil ends, mark off places on the outer edge of the core at points on the teeth where the coil band wire clips should come. These points should be located about 3/8 in. from the outer edge of the tooth. Now in some convenient way, as with a file, cut down the surface of the marked teeth to a depth of 3/8 in. and to a width equal to the thickness of the band wire tie clip and two thicknesses of insulation, as is shown in the top diagram of the accompanying illustration. After this has been done to all of the teeth that were marked, separate the laminations with a small, sharp-pointed chisel in each tooth, as is shown in the illustration.

Then insert in the small slot, one end of the band wire clip with insulation on each side of it, letting the band wire clip stand vertical as shown in the top illustration. Prepare the surface of the coil ends with insulation to receive the band wire. After this is done, bend the clip to a horizontal position. These band wire clips should be made long enough so that when they are bent over with one end insulated in the slot in a tooth, the other end of the clip will extend about 1/4 in. beyond the edge of the band wire. After the band wire has been wound on, the extending end of the clip may be turned back over the band wire and soldered in the usual manner, as shown in the bottom illustration.

We are now ready to lay on the special band; that is, the one that is shown at the left in the bottom illustration. This is a core band. See that insulation of suitable thickness is placed over the outer end of the core. One edge of this insulation should project about 1/4 in. beyond the edge of the core so as to allow the band wire to be put on as near the edge of the core as practicable and thereby hold the inserted end of the outside band clip from raising and coming out of the small slot in the tooth. Careful examination of the bottom illustration will show how the clips holding the band going over the coil ends are anchored in the teeth of the core by the core band. I. F. WISINSKI.
Chicago Elevator & Electric Mach. Co.,
Chicago, Ill.

* * * *

L. T. M.'s trouble is rather common, but he has an aggravated case because of the copper strips with which he has tied together the armature bands. Ordinary banding heats an armature in two ways: First, by losses in the bands; and second, by restricting the ventilation and preventing the dissipation of heat from the armature core and coils.

According to T. Spooner, in the January, 1926, number of the *Journal of the A. I. E. E.*, band losses may be classified as follows: (1) Eddy current losses in band wires, solder, and tinned strips, due to radial flux. (2) Eddy current losses in band wires, solder, and tinned strips, due to tangential flux. (3) Normal hysteresis loss in band wires and strips due to tangential flux. (4) Additional hysteresis losses due to displaced hysteresis loops. (5) Additional armature tooth

loss (eddy currents) due to the damping out of the flux by the bands in the region of the pole tips, thus producing flux across the laminations, which may result in extra eddy current losses.

Mr. Spooner also gives the following factors as affecting band losses: (*a*) Width of bands; (*b*) Width of teeth at air gap; (*c*) Size of band wires; (*d*) Amount of solder used; (*e*) Dimensions of tinned strips and clips; (*f*) Normal resistivity of wire, solder, and tinned strips; (*g*) Temperature of bands; (*h*) Frequency; (*i*) Induction, in both teeth and bands; (*j*) Field form; (*k*) Air gap; (*l*) Depth of band groove.

From the above it may be seen that armature banding is not such a simple thing as it seems. Band temperatures may run up to 200 deg. C., or more, and band losses may amount to 2 or 3 kw. under certain conditions.

Returning to fundamentals, however, when a conductor which is part of a closed circuit cuts through a field of magnetic flux, a current is induced in it. The direction of the current is at right-angles to the direction of the flux and at right-angles to the direction of motion of the conductor. This relationship may be remembered by the right-hand rule. Extend the figures in the direction of the flux (out of a north pole or into a south pole) with the palm of the hand directed so that the movement of the conductor will bring it into the grasp. The induced current will be in the direction of the thumb when parallel to the conductor.

It is by induction that the current is set up in the coils of a generator. The relative movement between the flux and the conductor produces the flow. In a d.c. generator the conductors move through the flux, but in an a.c. generator the flux moves across the conductors; the result is the same in either case, as lines of magnetic force are cut by the conductor. As the conductor passes under a north pole the current flow will be in a given direction; then as the conductor moves under a south pole the current flow is in the reverse direction. This causes the generation of alternating current.

Consider the rotor of a squirrel-cage motor. In it there are a number of conductors across the face of the core from end to end and embedded in slots. These are connected together by end rings which may be of low or high resistance depending upon the work for which the motor was designed. This motor operates because of the induced current in the rotor conductors, which sets up magnetic fields of flux which are linked with the conductors.

L. T. M. has, in effect, constructed a squirrel-cage winding, with very high resistance rings, over the armature winding of his motor. Currents are induced in the copper strips and bands, which produce heating by ohmic resistance. Even if the bands were not connected together, there would be some losses due to this cause, as indicated in points (1) and (2), in the fore part of this discussion. For this reason the bands are made of wire instead of strap and they are usually made narrow and insulated from each other.

Points (3), (4), and (5) in the preceding, cover losses due to reversing magnetism setting up internal stresses in the steel parts, thus causing heating. Attempts have been made to use non-magnetic materials for banding but no satisfactory results have been obtained because of the strength required of the bands.

Armature bands must be kept from contact with the armature core. When coils or wedges are not high enough to do this, insulation should be put under the bands; otherwise, closed circuits will be formed by the rings, laminations of the core, and the armature shaft.

The bands should not be connected together for the reasons set forth in the preceding. It is believed that if the coils are properly placed in the slots and the bands wound on with sufficient tension on the banding wire, there will be no slipping of the bands in the operation of the motor.

Electrical Engineer, D. W. BLAKESLEE.
Jones & Laughlin Steel Corporation,
Pittsburgh, Pa.

* * * *

In reply to the question by L. T. M., the heating of the copper ties is caused by heavy induced current. These ties in conjunction with the band act as a shorted coil of one turn and low resistance, with a consequent heavy current flowing through it.

To prevent this induced current, the copper ties can be placed at points around the armature where they will be under like poles at the same instant, with the result that little or no voltage will be induced.

In a four-pole machine we are limited to two ties, in a six-pole machine, three ties, and so on. The number of ties equals the number of poles divided by two, and must be spaced accurately to obtain the desired results.

Brooklyn, N. Y. MICHAEL REUTER.

* * * *

In a recent issue L. T. M. asks how to remedy some trouble he is having with armature bands heating on a 220-volt, direct-current motor. One of the causes of this kind of trouble is that the armature bands are not insulated from the core of the armature. L. T. M. writes that they are insulated from the winding, but that in itself is not enough, for the band must also be insulated from the core. We frequently run into this kind of trouble in a shop that I operate and always correct it by insulating the band from the core.

There is also another source that may cause the trouble L. T. M. is experiencing. He probably knows that the way current is generated is to revolve a copper wire at right angles to lines of force in a magnetic field. It is not necessary that the wire be in the slots of the armature, for the current would be generated if the armature coils were fastened to the outside of the armature. It is also known that if an armature coil is wound through the slots of an armature and the ends of the coil tied together, the coil will heat and burn the insulation.

What L. T. M.'s armature winder does when he ties the bands together, is to put on the outside of the core of the armature a copper wire, or rather five of them, that cut lines of force in a magnetic field which causes a current to flow through them. The band wire completes the circuit through the copper tie strips. The current induced in these strips causes them to heat and melt the solder on the bands. To correct the trouble that he is experiencing, he will have to insulate the copper tie strips from the banding wire.

Norton, Va. WILLIAM HANKS.

* * * *

Answering L. T. M.'s question, I would say that the reason the banding wire on the armature heats up is on account of the strips of copper being parallel to the armature coils. When the armature is rotating, these strips of copper are cutting lines of force the same as the armature coils, and since these strips are connected together by means of the core band, a path is made for the induced current to flow and thereby cause the tie strips of copper and the core band to heat.

If L. T. M. would fasten the strips of copper from the end band to the first core band and not to all of the five bands, I have no doubt that he will not have any more trouble from hot band wires. CHARLES H. MCSPERRITT.

Newark, N. J.

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Not knowing the horsepower and revolutions per minute of L. T. M.'s motor, about the quickest way to remedy his trouble is to use a non-magnetic banding wire, such as bronze or piano wire. If he cannot get this kind of wire, he can successfully use steel banding wire even though it is a magnetic material. He can overcome the heating due to magnetic action by using as few turns of banding wire as the speed and size of the armature will permit. With a total of five bands, the core bands should not be connected together with strips; however, the end core bands can be connected with a clip to the end coil bands.

Ninety per cent of all band failures are due to loose bands from poor soldering, from too wide a band on the core, and from end coil bands not being put on properly. The end coil bands whenever possible should be located in a hollowed-out position or sort of valley in the middle of the coil ends. End coil bands should be kept as far away from the core as possible in order to secure the best results. The larger the size of the banding wire the better, but make sure that the core bands are not too wide or too heavy.

A way of getting around the heating of bands is to separate the individual wires by putting a piece of cord between each turn of band wire. The result is that a band is wound on having each alternate turn made of cord. Now remove the cord and pull the wires together only at the clips and solder them well.

Always remember that a band should never be grounded to the windings of the armature.

Newark, N. J. SAMUEL CARBAT.

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Answering L. T. M. there are probably two reasons why the bands on the armature in question heat up. The first and most important reason

is that since the copper strips lie parallel to the armature conductors, a current of low voltage and high amperage is induced therein. The circuit is closed through the bands, making several parallel circuits. The other reason is due to eddy currents being set up in the first band next to the core due to the radial (magnetic) flux between poles. While usually this is not considered very seriously it may have quite an appreciable value due to the manner in which the bands are tied together in this particular instance.

There are three ways of overcoming the trouble. The first is to put the usual steel band at the end of the core and start a string band (we use seine twine) at the small end of the winding, making a solid band nearly up to the steel band. If trouble is experienced in starting the band, a few turns of friction tape may be put on at the starting point in such a manner as to make a flat place for the start. The string should be well saturated with varnish after it is put on, two coats usually being required. A second method is to build up two flat places about ¾ in. or 1 in. wide on the slanting surface, with friction tape and heavy fish paper, these being held from slipping by strips brought from the top band in the same manner as L. T. M. used on his bands. Note that the strips are used only to keep the built-up material from slipping and must be insulated from the bands themselves. A third method is to build up the space under the leads with suitable material so that when the leads are laid they will lie nearly parallel with the axis of the armature for a length sufficient for proper banding. Obviously the latter method is not practicable except when the armature is being rewound.

We use the first method on one type of armature; it makes a fairly neat looking job and if the string band is well saturated with varnish and dried, it will properly hold the conductors and the band will not come off.

A quick-drying, emergency compound for saturating the string band may be made by dissolving powdered rosin in alcohol, using an old egg beater for mixing. The alcohol can be evaporated in a few minutes by an air blast after which heat should be applied for about ½ hr. with a space heater or otherwise; the rosin will harden as the armature cools. L. T. M. asks what causes the current to flow in the bands. This is caused by induction in the same manner as the secondary winding of a transformer is energized by the primary, the current in the armature conductors being, of course, alternating. Briefly the action is as follows: When an alternating current passes along a conductor it sets up a magnetic flux around it which increases in value. A good analogy of this is the expansion and contraction of the hairspring in a watch or an alarm clock. This flux encircles any other conductor in the immediate vicinity, passing by it first in one direction and then the other, thereby setting up an induced electromotive force therein. This electromotive force causes a current to flow through the closed circuit that L. T. M. has provided by tying the bands together with copper strips. This current causes the heat that he is seeking a remedy for.

A more complete description of how voltages are induced as described in the foregoing, may be found in "Elements of Electricity" by Timbie and "Lessons in Practical Electricity" by Swoop. CHESTER A. WILLIAMS.

Electrical Dept.,
Providence Gas Co.,
Providence, R. I.

* * * *

Laying Out Electric Repair Shop for Steel Plant.—We are planning to build a new shop for doing our electric repair work. This shop will handle the necessary repairs on motors and control in a steel plant having about 1,000 modern motors both a. c. and d. c. During normal operation 14 men are required in the shop. Naturally the shop will have a coil-winding section; so provision must be made for winding equipment and supplies. In addition there will be a lathe, insulation cutting shear, baking oven, armature press, test rack and other shop equipment. I would like to obtain the views of readers as to what would be the most practical layout of a repair shop for this class of work. Possibly they have found certain arrangements of repair shop equipment that have produced money-saving results.
Indiana Harbor, Ind. A. R. D.

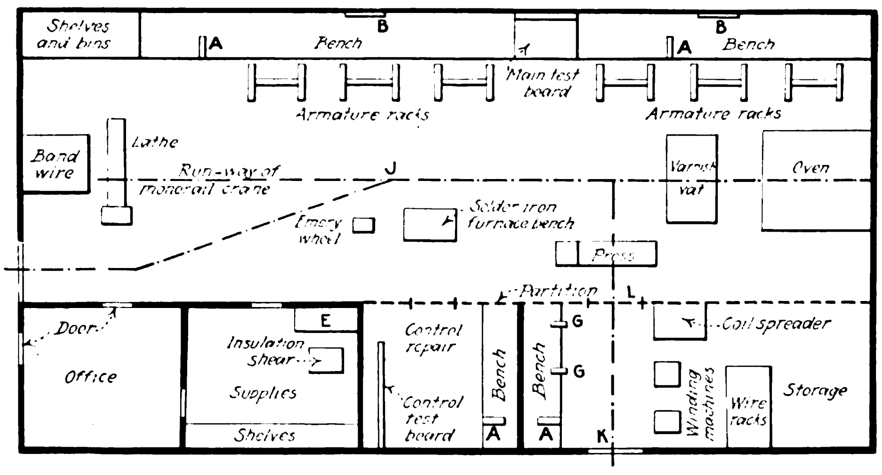
In answer to the question by A. R. D., I would like to offer the accompanying sketch of a shop layout, which combines the best points of several repair shops that I have seen. In this sketch the dotted line is a partition which may or may not be put in, according to the ideas of the management. I believe, however, that it will pay to put it in because of the fact that each department is thereby isolated and the distractions due to testing will not affect any other department.

A in the sketch represents a bench vise, four of which are shown; of course, it is not absolutely necessary to have this number, but they will save time, when installed at the positions shown. *B* is a small testing board which consists of a buzzer with series test leads; four pony receptacles, wired series-multiple; and series-test leads for testing d.c. armatures with a telephone receiver, if this method is to be used. All high-voltage tests will be made at the main test board which should be arranged so that 5,000 volts a.c. may be obtained for ground tests on 2,200-volt equipment. Likewise, a.c. and d.c. voltages should be on the board to test motors used or repaired in the plant. A large growler should be suspended overhead for testing d.c. armatures for shorts and partial shorts. The emery wheel stand and bench for supporting the furnace for heating soldering irons are shown in a central location. *E* is an insulation rack in front of which is the insulation shear (note that this shear is in the supply room). A man or boy should be in charge of this supply room, who is capable of cutting insulation to winders' measurements and the cutting waste should be used on small jobs. This man can, in his spare time, also lay in a stock of insulation cut to the sizes most frequently used. *G* indicates taping machines for coils.

A monorail, shown here in dotted lines, with two 1-ton blocks will be necessary. It will be advisable to put a switch in this monorail, as shown at *J*. *K* is an outer door which should be able to accommodate with plenty of clearance, the largest apparatus which has to be repaired. *L* is a small door in the coil department for the convenience of the men who strip and clean coils that are to be rewound. Small stators can also be burned out conveniently in this part of the shop. One or more racks should be provided for coils that are to be dipped. These coils can be handled by the chain block on the press monorail and shunted to the main monorail by aid of another block. The band wire is racked behind the lathe entirely out of the way. Unless the lathe is reversible, one or more rollers will be necessary on the apron to bring the wire to the front for banding.

The shop should be well lighted, warm in winter and as cool as possible in summer. Winding is tedious work under the best of conditions and the nearer ideal conditions are obtained, the greater the capacity of the workmen. Six armature racks are shown, which should have rollers about 4 in. in diameter and should be adjustable as to length. One or more heavy tables should also be provided for supporting stators while being rewound.

GRADY H. EMERSON.
Birmingham, Ala.



Due to the convenient arrangement of equipment, this electric shop layout will save time of workmen and speed up repair operations.

Electrical Service

around the works

For this section short articles describing ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing, and emergency or special installations.

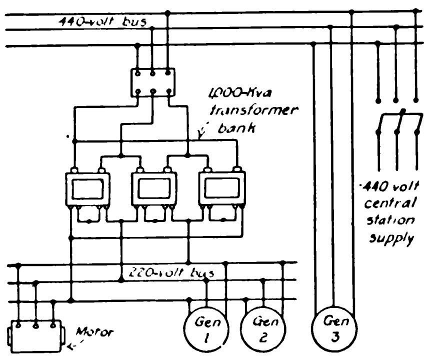
Saving Made by Elimination of Lightly Loaded Transformer Bank

FOR industrial plants which generate their own power during the day, and purchase auxiliary power for night lighting or occasional motor use, it is advisable from an economic standpoint to have the motors that are used at night of the same voltage as that of the central station supply, as will be illustrated in the following example.

The power supply of a certain large industrial plant was as shown in the accompanying diagram. Generators *1* and *2* were both rated 220 volts, three-phase, while generator *3* was a 440-volt, three-phase machine. The connected plant load consisted principally of 220- and 440-volt motors. This arrangement was the result of combining old and new equipment and was designed with the idea of ultimately changing entirely to 440-volt service.

It was found necessary on certain work to operate a 40-hp., 220-volt motor for 14 hr. each night over a period of several years. This necessitated operating one of the 220-volt generators at night or using purchased power which was already in use in the plant. Naturally it was much cheaper to use the purchased power, however this power was supplied at 440 volts and since the motor was rated at 220 volts, using purchased power necessitated switching in the 1,000-kva. transformer bank normally used for changing the voltage from 440 to 220.

Through the use of an indicating wattmeter on the central station power feeder, it was found that at very light loads the transformer bank had an excitation load of 16 kw. This represented a waste of power that could



The 40-hp., 220-volt motor was reconnected for 440 volts and fed from the 440-volt bus, thereby eliminating the transformer bank.

be avoided by the use of a 440-volt motor, as it would then not be necessary to use the transformer bank at night.

Accordingly, the connection of the stator coils was changed from parallel to series, and the motor cables were tapped onto the 440-volt feeder.

The saving made possible by elimination of the use of the transformers was 16×14×0.031 (cost per kw.)×300, or $2,082 per year. The labor and material cost for reconnecting the motor was approximately $65. A better power factor was obtained and the line losses between the motor and switchboard were also decreased somewhat.

Jersey City, N. J. E. A. BAERER.

Loss of Torque in Changing Squirrel-Cage Motor to Wound Rotor Design

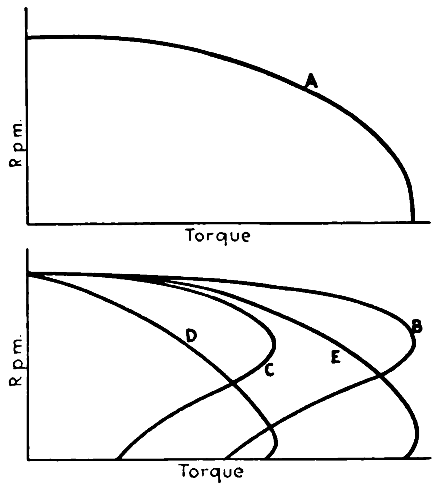
IN ONE power plant a KTR, 30-hp. motor was used to operate a coal hoist. It was desired to change this over to a slip-ring motor by using a new rotor, and obtain the same maximum torque value. A high-resistance motor like the KTR has a secondary resistance of such value that its starting torque is very nearly equal to its maximum torque and the speed-torque characteristics are similar to curve *A* in the diagram. Any decrease in the rotor resistance would decrease the starting torque, although the maximum torque would remain the same. Such a condition is shown by curve *B*.

It might be expected that the new, low-resistance, slip-ring rotor would give a torque similar to curve *B*. By inserting the proper value of resistance in the motor secondary one might assume that a torque curve such as *E*, would be obtained, which would be practically identical with curve *A*. The only difference would be that in curve *A* the secondary resistance is contained in the high-resistance rotor of the squirrel-cage motor and in curve *E* the resistance is external to the motor, being contained in the resistance boxes of the slip-ring motor. This is a natural assumption because the maximum torque of an induction motor is independent of the secondary resistance. The starting torque varies only with changes in the secondary resistance, irrespective of whether this resistance is internal or external to the secondary winding of the motor.

As a matter of fact, the basic curve obtained with the low-resistance, slip-ring motor is shown at *C*. Inserting the proper amount of resistance in the secondary gives a maximum starting torque, as indicated by curve *D*, which is considerably less than indicated by curve *B*. The reasons for this will be explained.

First, the squirrel-cage rotor has its rotor bars short-circuited by end rings, whereas the wound rotor has end connections which cause self inductance.

Second, the construction of the squirrel-cage rotor is such that the minimum possible air gap is maintained, whereas the wound-rotor winding is imbedded in the rotor iron and the air gap is increased due to the presence of insulation and wedges. The net result is that there is a considerable decrease in the flux of the motor. Decreasing the flux of an induction motor decreases the maximum torque obtainable as is indicated by curves *C* and *D*. In order to obtain a torque more nearly equal to curve *A*, it would be necessary to rewind the stator with a winding having lower losses, which would increase the flux. Rewinding of the stator would improve the torque characteristics to a certain extent, but would not bring the maximum torque up to the original value obtained with the squirrel-cage rotor, due to the inherent characteristics of the wound



Speed-torque characteristics of high-resistance squirrel-cage motor, and wound-rotor motor with resistance added to secondary winding.

The speed-torque curve of a high-resistance, squirrel-cage motor is shown at *A*. The effect of decreasing the squirrel-cage rotor resistance is shown in curve *B*. *C* is the basic curve of a low-resistance, slip-ring motor, and *D* is the curve obtained after inserting resistance in the secondary circuit. Curve *E* represents the speed-torque values which it might erroneously be assumed could be obtained by adding the proper amount of resistance in the secondary of the slip-ring motor.

rotor as was previously mentioned.

It should also be noted that the starting torque of a wound-rotor motor will be less than that of a squirrel-cage motor because of the positional factor. Also, due to the bars of a squirrel-cage motor being short-circuited, the torque at one position of the rotor will be practically the same as at any other position. If torque is an important consideration when it is desired to change a squirrel-cage motor to a slip-ring motor by changing rotors, it is important that the new torque characteristics be checked by the designing engineers of the company which manufactures the motor in question.

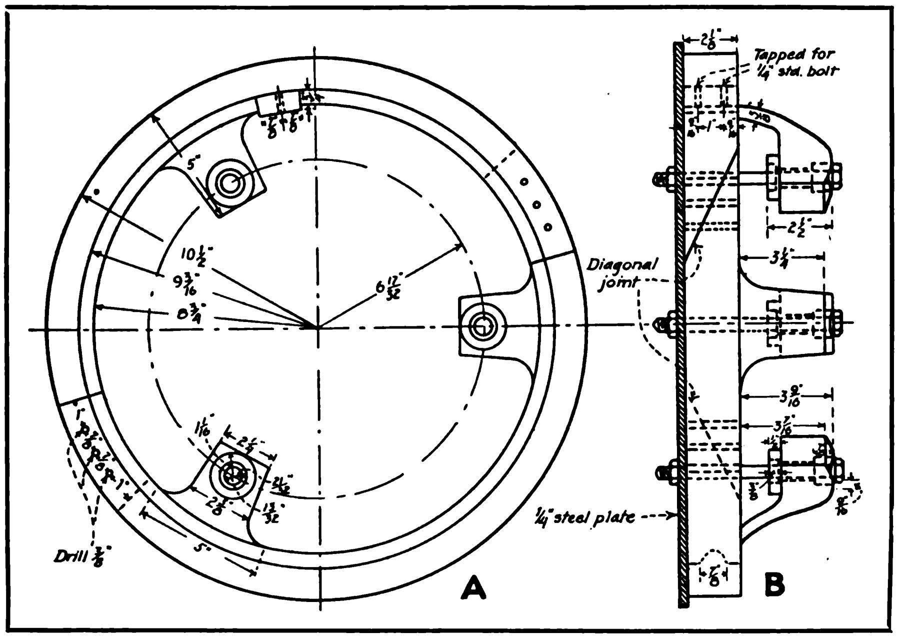
R. F. EMERSON.
Industrial Engineering Dept.,
General Electric Co.,
Schenectady, N. Y.

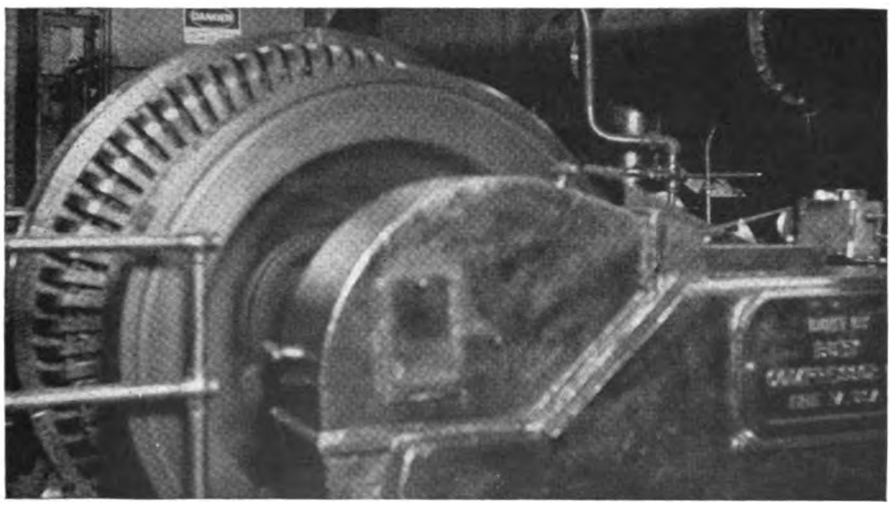
Method of Replacing Motor Collector Ring Under Difficulties

THE AIR compressor shown in the illustration has been in service four years, and is driven by a 200-hp., three-phase, 60-cycle, 2,300-volt, 250-r.p.m., synchronous-type motor with 125-volt excitation. The rotor shaft of the motor carries the flywheel and pulley for the belted exciter, the collector rings and the eccentric arms, all on the same end. The collector rings on the rotor are of the solid type and are bolted on the spider by projecting bolts at three points on each ring. These rings are made of cast iron, chilled on the wearing surface.

About six months ago the inside ring on this compressor motor developed several flat spots. We tried every means of grinding the ring by using a portable grinder with carborundum wheels and several makes of hand stones which were guaranteed to cut chilled, cast iron, but failed to do so in this case. We tried a cutting tool on this ring and belted the rotor to a variable-speed motor so that various cutting speeds could be obtained, but the tool failed to cut this ring at any speed available. Of course, we were handicapped from the beginning because of the small space available, as can be noted in the illustration.

This shows, A, dimensions of brass collector ring, with location of bolt holes for joints and, B, ring mounted on steel plate which served as templet after ring was cut in two. The problem of replacing a collector ring on this air compressor motor, without dismantling the outfit, was solved by installing a split, brass ring.





It was decided that the ring had to be taken out, but operations would not permit shutting down the motor long enough to remove the rotor; besides there was no lathe in this vicinity large enough to swing a rotor of this diameter. In addition to this, the flywheel pulley and eccentric arms would have to be pressed off the rotor shaft. We consulted the manufacturer of this motor about purchasing split rings, hoping to be able to install them without removing the rotor. The manufacturer advised that the design would not allow sufficient space for the usual type of split joint because of interference from the projecting spider bolts. So we decided to purchase from the manufacturer a solid brass ring made from the original pattern previously used for the cast-iron rings, and after receiving it we proceeded to cut joints in it. The dimensions of the ring are shown in *A* of the illustration.

The ring was first bolted to a piece of ¼-in. steel plate and joint bolt holes drilled, as shown in *B*. We then removed the ring from the steel plate and sawed diagonal joints in it, as shown, after which we mounted the ring on the plate again and added sufficient fillers to the joints to bring the outside diameter to the original size. Next we removed the good cast-iron ring on the compressor motor from its spider and placed it to one side on the shaft. After this we wrecked the old cast-iron ring with a hammer, installed the new brass ring and put the good cast-iron ring in place again. We found that the brass ring was out of round not quite 1/32 in. It was a small matter to grind the ring true at the normal speed of the motor, with either the hand stones or grinding wheels available. The job was completed in about 6 hr. and the compressor was put back on the line immediately. To date, the new ring has given perfect satisfaction.

Chief Electrician, J. S. MURRAY.
Follansbee Bros. Co.,
Toronto, Ohio.

Factors That Affect Safe Current Carrying Capacity of Copper Wire

THE proper size of wire to use for any current value is decided after consideration of at least one of three factors. These three factors are: the voltage drop in the wire, the value of the power lost in the wire, and the temperature rise because of this power loss. The first two of these items will vary directly as the resistance of the wire, but temperature rise depends not only upon the resistance, but also upon the ability of the wire to dissipate the heat that is generated within it.

The resistance of two wires, if they are made from metal of the same specific conductivity will vary inversely as their cross-section area. However, the ability to radiate heat will depend to a great extent upon the surface area which will vary as the circumference for wires of the same length. The cross-

section area of wire will vary as the square of its diameter, while the circumference varies directly with the diameter. Therefore, the radiating surface does not increase nearly as fast as the cross-section area and for this reason large wires cannot carry the same ratio of current in proportion to their circ. mil area as smaller ones.

An example of this decrease in the safe current carrying capacity as the wires become larger, may be found in a table prepared by the National Board of Fire Underwriters. According to this table, No. 14 wire with an area of 4,000 circ. mils has a carrying capacity of 15 amp. for rubber insulation, 18 amp. for varnished cloth and 20 amp. for all other insulation. This gives an average between 4 and 5 amp. per 1,000 circ. mils. For a wire area of 2,000,000 circ. mils, the carrying capacity averages around 1,300 amp., or has decreased to less than ¾ amp. per 1,000 circ. mil for the different insulated wires of this size.

Many electricians judge the safe-current-carrying capacity of a cable by the current density, that is, the number of amperes per 1,000 or per 1,000,000 circ. mils. As may be seen from the example given above, this is poor practice, since the safe current density decreases with the size of the wire.

G. H. McKELWAY.
Westfield, New Jersey.

Method of Checking Alignment of Bridge on Traveling Crane

TO PERMIT smooth operation, the track wheels on the bridge of a traveling crane and, in particular, the driving track wheels, must sit squarely with the rails. If the wheels are out of line with the rails, excessive binding will occur at the wheel flanges which will cause undue wear and may result in breakage of the wheels.

To maintain proper alignment, the drive wheels must be of the same diameter. One-eighth inch difference in diameter of two wheels driven from a common shaft will cause one side of the crane to advance more than ⅜ in. for each revolution of the drive wheels. Considering a 2-ft. wheel, this means an advance of 6¼ in. in 100 ft. of travel. In other words, with this difference in diameter between two wheels, one side of the crane will travel one-half of one per cent further than the other.

The diameter of all driving wheels on cranes should be frequently checked. On account of the limited room for measuring this diameter, it will usually be found most convenient to measure the circumference of the wheel by putting a steel tape around it. The circumferences of the wheels may thereby be directly compared. This is really more accurate than comparing the diameters of the different wheels.

Drive wheels found to have slightly different diameters must be replaced. We always match up our drive wheels in pairs, and consequently install them in pairs. Also, all new wheels are purchased in pairs. All wheels removed are checked for actual diameter, flat spots, and similar evidences of wear. Wheels with flat spots requiring the removal of 1/16 in. to ⅛ in. of material to bring them back to round, are ground. It costs us about $6 to remove ⅛ in. of metal. The chill is usable for about ¼ in.; so we are usually able to grind off up to ⅛ in. without going beyond the chilled surface on the wheel tread. Wheels are ground to match some other wheel if possible. Unmatched wheels are used for idlers.

Another common cause of misalignment, is from the slipping of the wheels in operation, due particularly to rapid deceleration and acceleration of the crane bridge. The crane should occasionally be run against the end bumpers to bring it back to square. However, to obtain any benefit from this, the bumpers must be kept rigid and carefully aligned so as to bring the crane bridge at right angles to the crane runway.

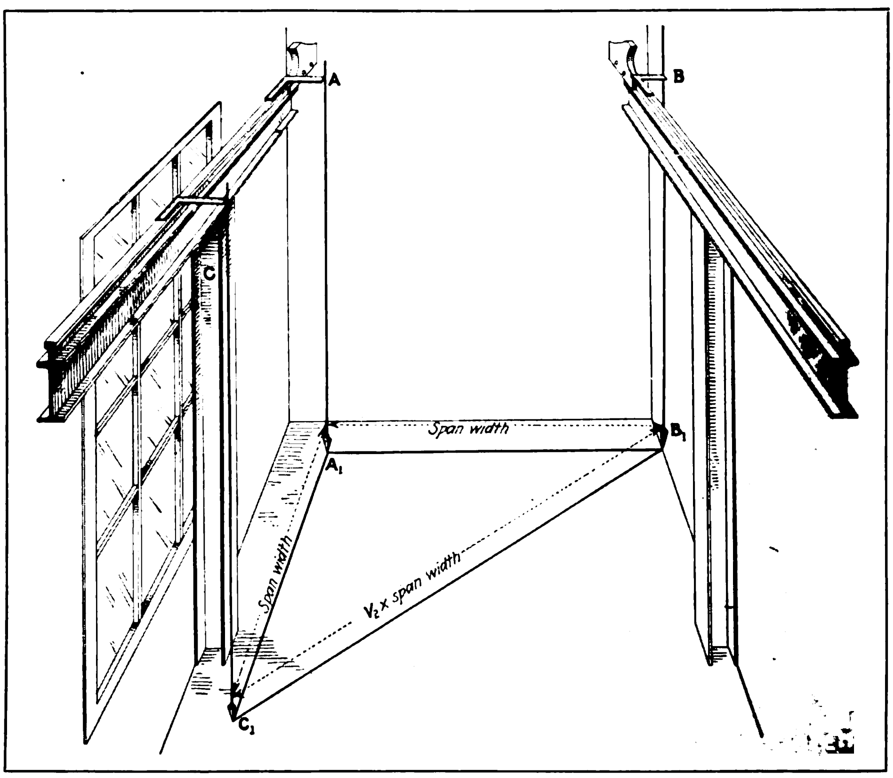
For checking the alignment of the bumpers, we have used the following method with very good results. Plumb bobs are dropped from each of the bumpers to the floor, as shown at *A* and at *B* in the accompanying illustration. Inasmuch as the rails on the runway prevent dropping the plumb bobs directly from the bumpers, a carpenter's square is placed against the bumpers and the plumb bobs dropped from the corner of the square as shown in the illustration. The distance from the center of the rail to the end of the square should be the same in every case where the square is used. In other words, the distance from the center of the rail to point *A* should be the same as the distance from the center of the other rail to point *B*; likewise, it should also equal the distance from the center of the first rail to point *C*. This will locate the points A_1, and B_1 on the floor beneath the crane runway. This distance is equal to the distance between the centers of the rails and is known as the span width. Now from the end of the bumper at the left, as shown in the illustration, measure down the rail a distance equal to the span width, as shown at *C*. By use of a square, drop a plumb bob from this point to the floor as at C_1.

We now have an isosceles triangle laid out on the floor as at C_1, A_1, B_1. If the angle at A_1 is a right angle then the bumpers are so placed as to bring the crane bridge to a right angle to the track runway; in other words, the end bumpers are properly aligned. If the angle at A_1 is a right angle, the distance from C_1 to B_1 will be equal to the span width multiplied by the square root of 2, or multiplied by 1.4142.

If this distance does not check, the point B_1 should be moved until it is at a distance from C_1 equal to the span width multiplied by the square root of 2, and also at a distance from A_1 equal to the span width. The new B_1 may now be projected up to the end bumper above it by means of a plumb bob, and the end bumper moved until it is in alignment.

This method may sound very complicated, but when it is actually tried out, it will be found to be very simple and the results obtained will be well worth while.

R. N. VINING.
Electrical Engineer,
Detroit Seamless Steel Tubes Co.,
Detroit, Mich.



For correct alignment, a line connecting the end bumpers should be at right angles to the rails.

By means of carpenters' squares and plumb bobs the span width *AB* is laid out on the floor, as shown at A_1 and B_1. Likewise, a distance equal to the span width is laid out on the rails at *A* to *C*, or as shown on the floor between A_1 and C_1. For the angle at A_1 to be a right angle the distance between C_1 and B_1 must be equal to the span width times the constant 1.4142.

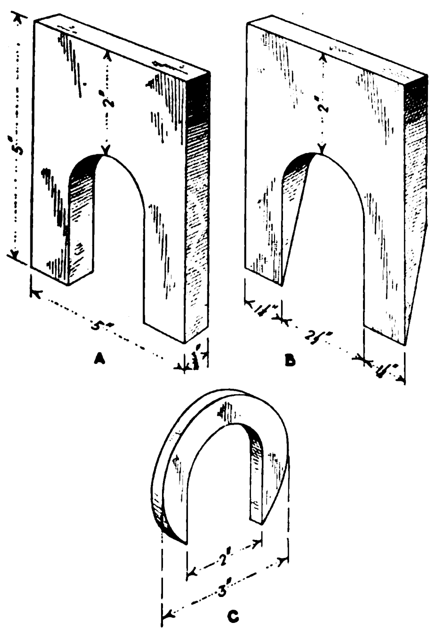
Mechanical maintenance of

Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through the auxiliary transmitting equipment to all driven machines.

Set of Wedges for Driving Pinion from Shaft

THE accompanying sketches show a set of wedges which I have used for driving off motor pinions where the space between the bearing and the pinion is too small to permit the use of a puller or a key-drift. These wedges consist of a flat steel plate with an opening as shown. A set consists of several wedges of the form shown as *A* and one tapering wedge *B* used for starting. All of these are of the same thickness. The tapered wedge *B* is driven in the full distance, removed, a straight wedge of the form *A* inserted, and the wedge *B* again driven in. Or, if preferred, a puller may be used after the pinion is started.



The set of wedges, A and B, are used to drive off motor pinions when they are very close to the bearing. The washer, C, is used to reinforce paper pulleys before using a puller or these wedges.

The wedges for use on a 25-hp. motor were made from a piece of steel 5 in. square and ¾ in. thick. This set is shown in the sketch. Wedges of proportionate size would be used on smaller shafts. With these wedges, the pinion on a 25-hp. motor was removed in a few minutes, although it had for several hours resisted all efforts to remove it by other means.

Another difficult problem is the removal of very tight paper pulleys by a puller, as the strain may loosen the fibrous body of the pulley from the hub. By using a slotted washer *C* against the end of the hub of the pulley to bring it flush with the edge, the strain is taken off the body of the pulley and transmitted to the hub. With this washer, either the wedges or a puller may be used on paper pulleys.

E. E. G. ROBERTS.
Southern Manganese Corp.,
Anniston, Ala.

Easy Method of Aligning Parallel Shafts

ONE method which I have found convenient for aligning parallel shafts such as a lineshaft and a countershaft or jackshaft, is shown in the accompanying sketch. This device consists of a length of 2-in. by 2-in. lumber, which has been dressed on all four sides for convenience in handling and marking, and a short length of 2-in. by 2-in. angle iron, fastened to it to form a T as shown. The inner faces of the angle iron must be free from rough rust spots or dirt which would prevent it from fitting snugly against the shaft. Also, the stick should be mounted so that it is at right angles with the angle of the iron.

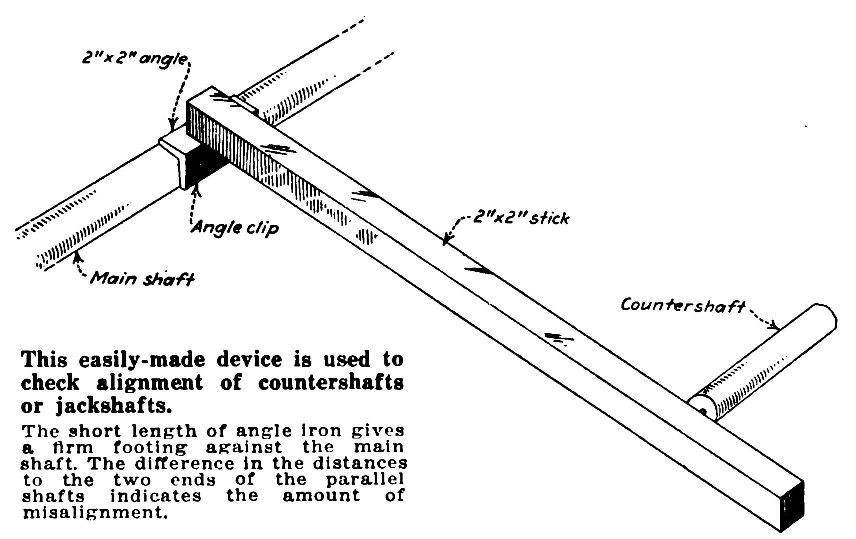
Wherever, it is possible to get at the ends of the countershaft or jackshaft, the angle iron is laid in place against the mainshaft as shown in the sketch, and the distance from the center or circumference of the countershaft or jackshaft is marked on the stick. This is repeated at the other end of the shaft and the distance between the two marks indicates the amount that the shaft is out of parallel. Correction for misalignment can be made with the adjusting screws at either or both ends of the shaft and the alignment again checked.

If the end of the countershaft or jackshaft is inaccessible, such as when it is in a bearing, the angle iron is laid against the main shaft as before, but the stick is placed across the top of the countershaft or jackshaft. The base of a carpenters' try-square is placed on the stick with the blade extending downward and pushed along until the blade comes in contact with the circumference of the countershaft. The position of the blade of the square is then marked on the stick and this line is compared with a similar line obtained at the other end of the countershaft. The difference between these line indicates how much it is out of alignment.

Before checking these alignments, the countershaft should, of course, be levelled. It is preferable to make these tests as near to the ends of the countershaft as possible, so as to get the greatest length possible between the checks.

This method has many advantages over attempting to use a string or laying a stick across the top of the two shafts and measuring with a try-square. The piece of angle iron need be only a few inches long and it is usually possible to find enough space on the main shaft free from pulleys to make these measurements.

MAURICE C. COCKSHOTT.
Hollywood, Calif.



This easily-made device is used to check alignment of countershafts or jackshafts.

The short length of angle iron gives a firm footing against the main shaft. The difference in the distances to the two ends of the parallel shafts indicates the amount of misalignment.

Estimating Horsepower Transmitted by Lineshafting

IN LAYING out lineshaft installations it is frequently desirable to make computations for different speeds and different sizes of shafting. Although this may be computed in each case, it is easier to determine the various capacities and ratings of different sizes of shafts at various speeds by the use of the accompanying chart. This chart was designed according to the following formula:

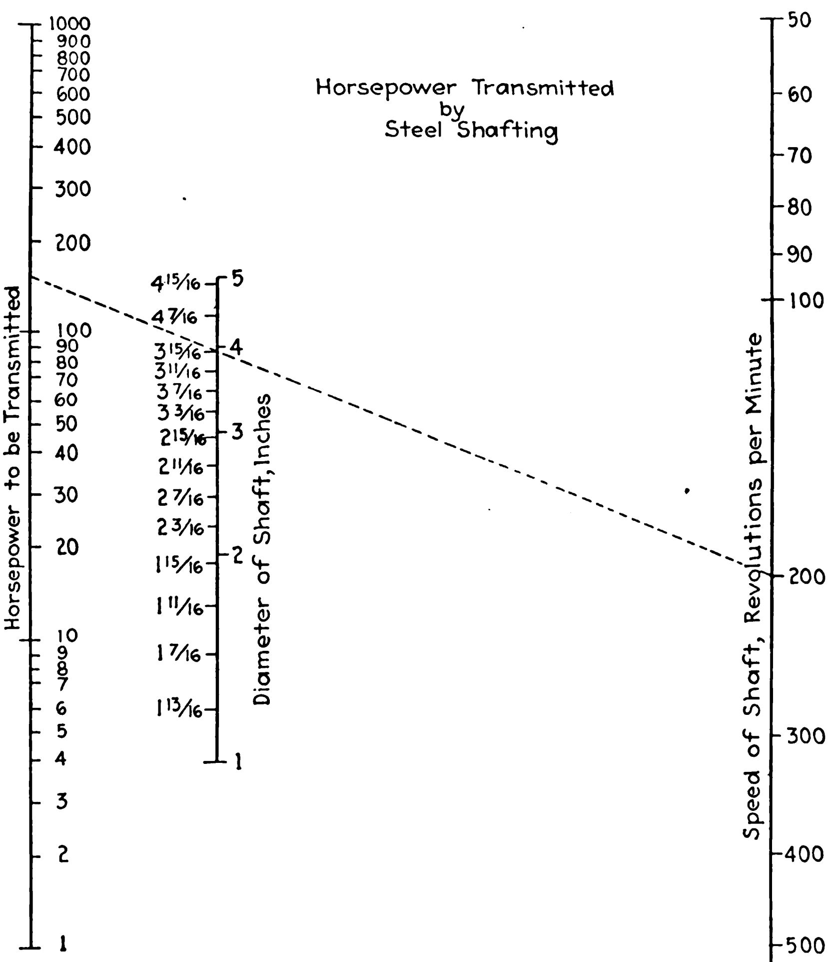
Diameter $= \sqrt[3]{(\text{hp.} \times 80) \div \text{r.p.m.}}$. This is a standard formula for determining the size of a lineshaft and applies only for standard construction where hangers are spaced on 8-ft. centers. The constant, 80, takes into account the installation of an ordinary number of pulleys driving machines and spaced within the 8-ft. centers. The main driving pulley should, of course, be on a section of shaft with the hangers placed closer together.

With this chart, horsepower transmitted, diameter of the shaft in inches, or speed of the. shaft, may be determined if any two of the factors are known.

The scale on the left, horsepower to be transmitted, has values ranging from 1 hp. to 1,000 hp. The center scale, diameter of shaft in inches, is graduated in the more common sizes of shafts used. The right-hand scale gives the speed of the shaft in revolutions per minute, over a range of 50 r.p.m. to 1,000 r.p.m.

The chart is used as follows: Place a straight-edge across the chart on the two known values, such as the horsepower and speed; and the intersection of the straight-edge and the center scale will give the size of shaft to use for the given conditions. Obviously, if any two values are known the third may be found by placing the straight-edge on the two known qualities. The intersection of the straight-edge and the third scale is the unknown quantity. CHAS. F. CAMERON.

Rock Springs, Wyo.



This chart is used for determining the horsepower transmitted by steel lineshafting when spaced on 8-ft. centers.

The method of using this chart is best explained in connection with an example, such as determining the diameter of shaft which will transmit 150 hp. at 200 r.p.m. To determine this, place the straight-edge on 200 r.p.m. on the right-hand scale and on 150 hp. on the left-hand scale. Read the value on the center scale at the intersection with the straight-edge. A 3 15/16-in. steel shafting may be used under the given conditions.

Selecting Proper Babbitt for Armature Bearings

BABBITT metals may be divided into lead-base and tin-base metals. The former finds far wider application on electric motors, as it is somewhat cheaper and gives very satisfactory service. The friction co-efficient is somewhat lower for lead-base babbitt, which is not quite so hard as tin-base babbitt. For general-purpose motors in coupled, belted, and ordinary geared service, the results are very satisfactory. Where very high speeds are encountered, tin-base babbitt is preferred, on account of its lesser tendency to "gall" or wipe.

Lead-base babbitt must be handled with great care; it has been found that the best temperature for handling this babbitt is around 460 to 490 deg. C. (860 to 914 deg. F.). If handled at temperatures much below the low point, segregation is likely to occur; if handled at higher temperatures and exposed to them for a considerable length of time, oxidation will occur and the metal may be ruined.

On motors used for severe service where vibrations are not only severe, but of a hammer-blow nature, it is preferable to use a bronze shell, tinned, and lined with babbitt, about 1/32 in. thick. The bronze is used for the purpose of insuring proper amalgamation, the babbitt being virtually soldered into place. With only a thin layer of babbitt, there is not much tendency for it to pound out of shape, as it is supported by the harder bronze.

Bronze shells without babbitt are not used to any great extent on electric motors. Bronze has a higher co-efficient of friction and expansion, requiring a larger bearing clearance than is used for babbitt. The higher friction coefficient causes greater heat development and if the running clearance is held too small, it may happen that the bearing will be tight on the shaft and rotate with it in the housing. If the housing is strong enough to prevent expansion, the shell will be compressed and become tight on the shaft. On the other hand, expansion may break the housing.

The babbitt-lined, bronze shell insures a lower co-efficient of friction and hence less heating. In some cases, it has been found sufficient to merely heat the bronze shell and tin the bearing surface. The shell is bored out to size and after tinning, a sizing reamer is pushed through in order to smooth off the bearing surface, which still retains the tin coating, showing that the tin has amalgamated with the bronze.

This process has given good results, but the 1/32-in. thick coating mentioned before is better to use, since it has longer life. After all, the arrangement of oil grooves and provision for lubrication are very important factors in the life of a bearing, and have considerable influence upon its performance. A high-grade babbitt may not always give satisfactory results if the bearing is incorrectly designed or neglected. R. PRUGER.

Mechanical Engineer,
Westinghouse Electric & Mfg. Co.,
East Pittsburgh, Pa.

In the Repair Shop

This section is devoted to repair work on electrical and mechanical equipment. Special attention is given to shop or bench tools and short cuts or improved methods of handling work of this character. Contribution are always welcome.

Simple Motor-Generator Set for Testing A. C. Motors

OFTENTIMES in repair shops in which only direct current is available, it is necessary to test small single- and poly-phase motors after rewinding. The following information will be of help in solving the problem which is thus presented.

The first step is to secure a three-phase, 60-cycle, 440-volt, a.c. generator which should be driven by a shunt-wound, d.c. motor. If the largest a.c. motor to be tested is of 1-hp. rating, the motor that drives the generator should be of not less than 3-hp. rating at 1,800 r.p.m. This will give about 1.4 hp. at 750 r.p.m., when testing 25-cycle machines. A 5- or 6-hp. motor would give more satisfactory results, because the set could then be used to test motors larger than 1-hp. rating at higher frequencies. A 1,500-r.p.m. motor, with a suitable resistance in the field circuit to raise the speed up to 1,800 r.p.m., and an ordinary rheostat in series with the armature to reduce the speed below normal, may be used to drive the generator.

The accompanying diagram shows how armature and field control rheostats can be worked by the same switch arm. A 3- or 5-hp., a.c. generator, would be large enough if the motors to be tested do not exceed 1-hp. rating, however, with larger generators the voltage regulation would be better under different loads. A three-pole, double-throw switch and a rheostat in the rotor field circuit should be used for controlling the voltage of the generator, which should be wound for 440 volts in order to deliver 220 volts at the low speed required for 25 cycles. As shown in the diagram, when the three-pole switch is thrown to the right the stator windings are connected in star, and when thrown to the left, in delta.

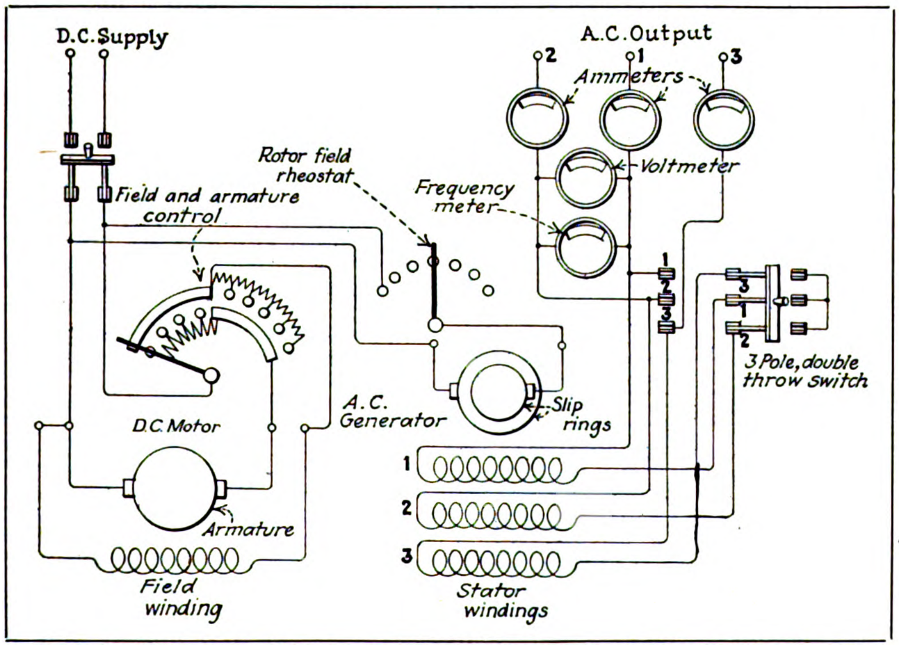
The following table shows the voltages that can be obtained for testing, by varying the speed and winding connections of the generator.

SPEED	CYCLES	CONNECTION	VOLTS
1,800	60	star	440
1,800	60	delta	256
750	25	star	220
750	25	delta	127

The voltages of 256 and 127 may be reduced to 220 and 110 volts respectively by regulating the field rheostat.

By adjusting the speed of the driving motor until the frequency meter shows the desired reading all frequencies from 25 to 60 cycles may be obtained. If single-phase current is to be used it may be taken from any two of the three generator leads. A voltmeter is necessary to ascertain the correct voltage and a frequency meter should be used to show the frequency of the set. Three ammeters are shown in the accompanying diagram. These will be of considerable help in locating trouble in a motor under test. One ammeter could be used, but it would have to be switched from one phase to the other. I once had a set like this made from two old 10-hp., d.c. motors and it worked very satisfactorily. A squirrel-cage induction motor will also make a good generator, if another rotor is installed in it. FRED LARSON.
Duluth, Minn.

Wiring diagram of motor-generator set for testing small a. c. motors.
The desired testing frequency is readily obtained by means of the armature and field control which controls the speed of the shunt-wound driving motor. The voltage is regulated by the rotor field rheostat, and the three-pole, double-throw switch. When this switch is thrown to the right, the stator windings of the generator are connected in star; when the switch is thrown to the left, the windings are connected in delta.



Vital Factors in Selection of Ovens for Baking Coils and Armatures

IN A recent issue of INDUSTRIAL ENGINEER I noticed an answer to P. F. W. of Pedro Miguel, Canal Zone. His question was, "What shop equipment will be required here?" I read over this answer very carefully and found that when the author came to the oven recommendations he gave sizes and mentioned that the oven should be built of brick or some other insulating material; also that the oven might be electrically heated if gas was not available, or that it might be fired by oil, or steam-heated.

I take exception to some of the author's statements and for the purpose of clearing up any misunderstandings which might arise I wish to call attention to the following facts.

An oven, to give good satisfaction, should not be constructed of brick, as brick and mortar absorb a great amount of heat, which is usually expensive. From actual tests, a brick oven for even operation must have heating units of 30 per cent greater capacity than an oven of the double-wall type, with only 2 in. of insulation, this being made up of mineral wool, 85 per cent magnesia block or other insulating material of equal value.

It has taken us over twenty years to determine the correct amount of ventilation for various sizes of ovens. Ventilation is one of the most important features of an oven when it comes to baking coils and armatures, for if the ventilation is too great,

waste of heat will be the result and under ordinary circumstances the oven cannot be brought up to temperatures high enough to bake properly. If the ventilation is not thorough enough, the oven will act sluggishly and it will be impossible to bake properly, due to the re-circulation of the fumes which are being carried off by the ventilation. Ventilation must be arranged so as to draw the heated air down through the top of the oven. This is done by having ventilating ducts on the floor of the oven, which brings the heat downwards so as to effect uniform heating in all parts of the oven. There must be some top ventilation, as the bottom ventilation carries off only the heavy gases while the top ventilation will carry off all the light vapors.

Another important point to consider in the ventilation of the oven is the fresh air ducts. Fresh air must be had for baking coils and armatures, due to the fact that varnish will not oxidize without it. This fresh air must be admitted uniformly and in the proper amounts to secure proper oxidation.

The author states that the oven might be electrically heated if gas is not available. If I were to equip a shop similar to the one mentioned I would reverse his statement, for gas, oil, and steam should be used only when electricity is not available. The following are the reasons for this statement: The average period of bake on armatures of large cross-sectional area is from 12 to 16 hr., and the temperature should be maintained within close limits. From our experience it is quite difficult to subject coils and armatures to a uniform temperature with a gas oven.

We would not recommend oil-fired ovens under any circumstances, as we feel that it is folly to have a flame of high temperature and small area in any part of the oven. A flame of this character will promote uneven heating, as the oven will be very hot in some places and cold in others. We frequently have inquiries for oil-burning ovens for coil and armature baking and in every instance we explain to the customer the difficulties with this form of heat.

The steam oven is not very practical, although it is used by large manufacturers who have considerable quantities of superheated steam. This condition is not found in the small coil and armature shop and, therefore, a steam oven cannot be used unless a steam boiler of high pressure is installed. To heat the oven to 200 deg. F. it is necessary to have superheated steam at high pressure. Unfortunately, even large plants who use this system have found it almost impossible to keep their ovens up to the proper temperature. We are now building an oven for one of the largest users of small coils in the world, and we do not guarantee the oven, unless they guarantee the steam pressure which we specify.

In taking up the subject of coil and armature baking it has been the writer's intention to promote a better understanding of oven requirements and it is for this reason that I called attention to the above factors. I feel that the average coil and armature shop does not understand what an oven should be capable of doing in order to turn out the work properly. I wish to see better conditions in this field so that coil and armature shops may turn out better work; that is, properly baked so as to give the best results. I know that if these shops would install the proper baking equipment, a great many large manufacturers would go back to them for repairs, instead of installing their own shops. One large manufacturer recently told me, when I asked him why he had put in his own shop, that there was not one commercial shop in his city equipped to do repair work that would hold up under the severe conditions in his plant. H. L. GRAPP.

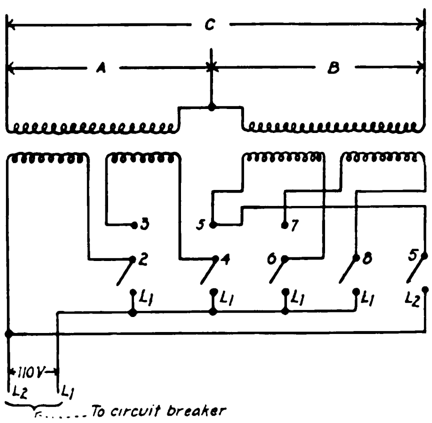
Sales Manager,
Despatch Manufacturing Co.,
Minneapolis, Minn.

How to Connect Two Testing Transformers for Various Voltages

IN ALL electrical repair shops it is necessary to have different voltages for testing purposes. On the other hand, it is a difficult job to rewind a transformer in the average shop and to bring out taps for all of the voltages desired.

An easy way of getting around this difficulty is to convert two 2200/220/110-volt transformers of the same size as shown in the diagram. From these the following voltages may be obtained: 4,400, 3,300, 2,200, 1,467, 1,100, 733, and 550. In this range there is a suitable voltage for any ordinary test. The table shows the connections for obtaining any of the above voltages. These connections may be left on the line for all voltages except 4,400, which should be taken off as soon as possible.

Detroit, Mich. C. H. FUNDERBURG.



Close switches so as to connect	Volts delivered at A	B	C
2 to 3, 4 to 5, 6 to 7, L_1 to 8	550	550	1100
2 to 3, L_1 to 4, 6 to 7, L_1 to 8, L_2 to 5	1100	1100	2200
2 to 3, 4 to 5, L_1 to 6	733	733	1466
2 to 3, L_1 to 4 L_1 to 6, L_2 to 5	1100	2200	3300
L_1 to 2, L_1 to 6, L_2 to 5	2200	2200	4400

The transformers are connected as shown in the diagram. By using the combinations of connections given in the table, the various voltages indicated may be obtained for testing.

Changing One-Coil-per-Slot Windings to Two Coils per Slot

THERE are a large number of induction motors in service in which the stator winding is of the type known as one-coil-per-slot windings. Examples of these are the basket winding used on the old Westinghouse Type CCL and HF stators, the concentric chain, mush-coil winding, and the group, two-layer-end, one-coil-per-slot winding. These windings are hard for the average winder to handle; therefore, it is often desired to change over to the more familiar two-layer, two-coil-per-slot, diamond mush-coil, flat or pulled. This article will discuss the various points of each type of winding and the method of developing the new winding. First, a few general rules and statements will be given after which each type will be considered separately.

The one-coil-per-slot winding always requires one-half as many coils as there are slots; that is, a 72-slot stator would have 36 coils, a 48-slot stator 24 coils, and so on. Coils per group, L, will equal total number of coils, C, divided by number of pairs of poles, P, times number of phases, K, or $L=C\div(P\times K)$. The number of coil groups$=(P\times K)$ or $C\div L$. When changing to a two-layer winding, the number of coils will equal the number of slots; therefore the number of groups=number of poles×number of phases and the coils per group will be the same as for one coil per slot. The coils per group and their arrangement is one of the points to check and the coil grouping tables and diagrams published in previous issues of INDUSTRIAL ENGINEER can be used for this work. The total turns per phase should be kept the same, unless changing the coil pitch requires the addition of turns, as will be explained later. The size of wire should be kept the same, unless the machine is worked hard and it is found that a larger size wire can be used; in this case, put in all the copper that slot and end room permit.

On the majority of one-coil-per-slot, mush windings, the ends of all the coils are taped from slot to slot with one, half-lapped layer of 0.007-in. cotton tape. With the basket winding, the ends of all coils are taped with one layer of half-lapped, 0.01-in., treated cloth tape and one, half-lapped layer of 0.007-in. cotton tape. Here is where considerable time and material can be saved when cutting over to a two-layer, mush-coil winding; for most industrial motor applications, the taping on the coil ends can be omitted and the finished winding given two or more dips in a black, plastic, insulating varnish and baked.

The following gives two standard methods of insulating mush coil ends for voltages up to and including 440 volts. (1) Use 0.023-in., combination slot insulation, fishpaper with treated cloth cemented to it. This has good mechanical and electrical characteristics. Tape all coils ends with one, half-overlapped layer of 0.007-in., cotton tape, reinforcing between phases with a piece of triangular, treated cloth. Dip

and bake the complete winding once in a good baking varnish.

(2) Use 0.023-in. combination slot insulation; do not tape the coil ends but insert a triangular piece of 0.01-in. treated cloth between each coil on both ends. The last coil of each pole-phase group may be taped with one, half-lapped layer of cotton tape and then dipped at least twice in a good, black, plastic varnish, and baked.

Whichever of these methods is best suited to the conditions should be selected. The distribution factor is not changed, as this is based on the number of slots per pole per phase and is the same for the same number of slots, poles and phases. The chord factor is changed only when the coil pitch is varied and in general the chord factor can be increased or decreased 8 per cent without adding or subtracting turns per coil or phase to compensate for the changed pitch.

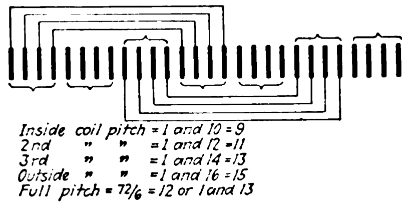
The following values of chord factors are based on per cent of coil pitch; full pitch equals 100 per cent and chord factor equals 1 or unity; 95 per cent pitch equals 0.998; 90 per cent equals 0.98; 85 per cent equals 0.97; 80 per cent equals 0.95; 75 per cent equals 0.93; 70 per cent equals 0.9; 65 per cent equals 0.86; 60 per cent equals 0.81; 55 per cent equals 0.76, and 50 per cent equals 0.7.

The per cent coil pitch of basket windings, two-layer, one-coil-per-slot, and two-layer, two-coil-per-slot windings, can be found as follows. First, find the full pitch, which is equal to total number of slots divided by the number of poles; that is for 72 slots, and four poles full pitch equals $72 \div 4 = 18$ or 1-and-19. Next, divide the coil pitch of the winding, expressed in slots, by the full pitch found. If present pitch is 1-and-16 or 15, per cent pitch equals $15 \div 18 = 0.833$ or 83.3 per cent. These general remarks apply to all types of windings.

Taking up each type of winding, the coil pitch in the basket winding must necessarily always be an odd number, or 5, 7, 9, 11, and so on, or 1-and-6, 1-and-8, 1-and-10, and so on, because one slot must be skipped between each coil as they are placed on the core. Also, the extensions of the coil ends in this type of winding are shorter than with a two-layer coil of the same pitch and turns. The short coil extension is due to the method of shaping the coils down against the iron. Thus it may be necessary in some cases to reduce the coil pitch in order to use a two-layer winding. A saving in slot and end room can be made by using single-cotton and enameled wire to replace the double-cotton-covered wire used in all of these windings.

Assume that we have a 72-slot motor, with 36-coil, basket winding, which it is desired to change to a two-layer winding. The basket winding requires only 36 coils, which means less time to make the coils and put them in the core. However each coil has to be taped on the ends with a layer of treated cloth and cotton tape and also requires shaping. On the other hand, with a two-layer winding we would have to make up 72 coils, but as the turns per coil are one-half the number in the basket winding, it would not require very much more time. Again, if it were decided to tape the ends, the taping time on the two-layer winding would be less, since there would be two layers of tape on each basket coil, which is equivalent to taking 72 coil ends. The taping of the ends for the two-layer winding would take a little less time and would also require less shaping. Unless a winder who is experienced on basket-type windings is available, the two-layer winding would make the best job.

The motor under consideration has a three-phase, four-pole winding, six groups, six coils per group, pitch 1-and-16 or 83.3 per cent, each coil having 14 turns of three No. 14 d.c.c. wires. The



This shows the procedure involved in changing a 72-slot, 6-pole, 36-coil, concentric chain winding from a one-coil-per-slot to a two-coil-per-slot winding.

two-layer winding data would be, as previously explained, 3 (phases) $\times$ 4 (poles) $= 12$ groups, six coils per group, 72 coils each having seven turns of three No. 14 s.c.e. wire, pitch 1-and-15, or one slot less, giving a 5.5 per cent decrease, which changes the pitch to 77.8 per cent. The reason for dropping one slot was to reduce the coil end extension and shorten the coil, reducing the weight of copper.

Assume that the end room available in the above case would permit a coil pitch of only 1-and-12, or 61 per cent. In this case, it would be necessary to add turns to each coil as follows: $(83 \times 7) \div 61 = 9.5$ or 9 turns per coil. According to this formula, new turns per coil equal old per cent coil pitch times the turns per coil for the two-layer old coil and divided by the new per cent coil-pitch. The per cent of coil pitch should be expressed as a whole number: that is, 83 not 0.83. Do not drop below 50 per cent pitch and when possible keep around 80 per cent.

Considering the next type of winding, it is one in which the coils are put on in groups. Although there is only one coil per slot, the ends are arranged in two layers; in fact, the coils resemble the standard two-layer, mush pulled coil. The coil pitch in this type of winding depends on the number of coils per group and the pitch will be even when the coils per group is an even number or odd when the coils per group is an odd number. The reason for this is that the coils are put on in groups; that is, with three coils per group, we first put in three coils in adjacent slots, then skip three slots and put in three more. The slots left empty are later used for the top halves of the coils. The only advantage to be had in changing this type of winding to a two-coil-per-slot winding is a slight decrease in end room and a lighter coil. If the ends of the two-coil-per-slot windings can be left untaped, then this latter winding would save time and material. The ends of the group winding are insulated in the same manner as the basket winding; with both these windings the extra insulation on the coil ends is necessary, due to the method of shaping and arranging the end winding. The same method of changing the basket type can be applied to the group windings.

Another type is the concentric chain winding. There is a decided advantage in changing this type to the two-coil-per-slot, two-layer winding for single rewind jobs, as the chain winding requires a number of different sizes of molds and some shaping. When there are a number of motors of the same kind to be rewound, the chain winding has the advantage as a gang mold can be made and a complete pole-phase group wound without cutting the wire, thus reducing the connecting time. The coil pitch of this type depends on the number of slots per pole per phase, as the pitch of the inside coil is selected so as to span a number of slots equal to the slots per pole per phase for two-phase motors. For three-phase motors the slots spanned will be the number of slots per pole per phase times two.

From this it is seen that the coil pitch will be both under and over 100 per cent. It should be understood that over-pitch has the same effect as under-pitch; that is, 120 per cent pitch is equivalent to 80 per cent pitch electrically, but the over-pitch coil requires more copper. These points can best be explained by an example: Assume a 72-slot, six-pole, three-phase stator with a concentric chain winding as shown in the accompanying diagram. The winding has 36 coils, nine groups, four coils per group and the end winding is arranged in two ranges, so that eight different sizes of coils are required.

According to the rule previously given, the slots spanned and left unused by the inside coils for three-phase, should be twice the number of slots per pole per phase. We have 72 slots or $72 \div 6 = 12$ slots per pole; $12 \div 3 = 4$ slots per pole per phase, and the pitch of the inside coil is $2 \times 4 = 8$, or 1-and-9. As indicated in the diagram the different coil pitches are as follows: full pitch is $72 \div 6 = 12$, or 1-and-13; the inside coil pitch is 9 or three slots under full pitch; the second coil pitch is 11, or one slot under full pitch; the third coil pitch is 13, or one slot over, which is equivalent to one slot under pitch, or eleven. Outside coil pitch is 15, or three slots over, this being the same as three slots under pitch, or 9, and the average coil pitch equals $9 + 11 + 11 + 9 \div 4 = 10$. In order to obtain the same average chord factor with a two-layer winding, the coil pitch should be 10, or 1-and-11. If the coil-end extension with the 1-and-11 pitch is too great, the pitch can be decreased as explained by varying the number of turns per coil.

The foregoing rules and details explain the points that require checking and consideration when changing over any of the types of windings mentioned to a two-layer, diamond-shape, coil winding. The best type of coil to use for the two-layer winding is the mush pulled coil, as this type of coil requires less shaping when winding the stator.

Wilkinsburg, Pa. A. C. Roe.

New Equipment

for plant operation and maintenance

Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these new devices which are designed to improve plant operation or reduce operating and maintenance costs.

Plate-Type Field Rheostats

A NEW line of field rheostats of the round-plate type in which the cast-iron plate previously used has been superseded by pressed steel, has been placed on the market by the Ward Leonard Electric Co., Mount Vernon, N. Y. This type of plate can be furnished completely inclosed, including the terminals. As in the case of the cast-iron, plate-type rheostat, the resistive conductor, its contacts and the joints between the contacts and the resistive conductor, are completely embedded in vitreous enamel.

Portable Rail Bond Tester

THE new Type BBT Bond Tester and the Type B Contact Bar are announced by Roller-Smith Co., 233 Broadway, New York City. This new, portable, direct-reading bond tester is designed for applications where the current in the rail is feeble or at the ends of trolley lines where no cars are running beyond the points where tests are being made.

It is stated that this bond tester has over five times the sensitivity of any bond tester heretofore made. It can be successfully used with the current from a single No. 6 dry cell. The special contact bar carries a bracket for this dry cell, with the necessary battery switch and contacts.

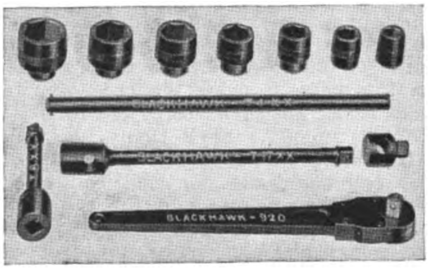
Strap Copper Bar Bender

THE machine in the accompanying illustration is announced by the Armature Coil Equipment Co., 2415 Forrestdale Ave., Cleveland, Ohio, for bending insulated or bare strap copper bar over its edge. The manufacturer states that in bending cotton-insulated copper bar it will not destroy one thread at the bend, and bends bars with any other insulation equally well. This machine can be used to bend one or more loops at a time and is provided with a stop limit to insure uniformity of shape. The machine can be adjusted to make any size of loop within its range. The loops are formed by two bending arms.

These machines are made in two sizes. The small size has a capacity of stock for one or more loops of any thickness up to ½ in. and ¾ in. in width. The capacity of the larger machine is bar stock 1 in. thick, up to 1¼ in. in width. Loops on the small machine may be bent over a ½-in. radius; the larger machine bends loops over a 5-in. radius.

Quick-Detachable Wrench Set

THE No. 12 quick-detachable industrial wrench set, as shown in the accompanying illustration, has been placed on the market by the Blackhawk Mfg. Co., Milwaukee, Wis. This is an extra-heavy-duty set, designed for service in shops and industrial plants.



The set includes a 20-in. ratchet wrench handle, one sliding bar 1 in. in diam. and 24 in. long, one short extension ⅞ in. in diam. and 9 in. long, one 18-in. extension, one offset adapter, and seven hexagon sockets for bolts; ranging from 1¼ to 2⅜ in. in size. The set weighs 46 lb. and is contained in a wooden box.

Changes in Lowering Switch

A NUMBER of improvements in the Thompson safety lowering switch or disconnecting hanger have been announced by The Thompson Electric Co., 1438 W. 9th St., Cleveland, Ohio. To make provision for easier inspection and cleaning of the parts, when it is necessary, the design of the new underslung model has been changed so that all of the moving parts except the wheel come down to the ground when the lamp is lowered. The hanger should be operated frequently enough to prevent the parts from becoming sticky from dirt or corrosion. The latchdog is so designed that it can be easily and quickly removed for cleaning. Another improvement provides for enclosing the line wires as they enter the upper member of the hanger. Still another change provides for a swiveling arrangement for dead-ending the chain in the lower member, thus enabling the lamp to rotate freely so as to bring the contacts into proper alignment for seating into each other. Provision is also made for enclosing the chain in conduit.

Small Reducing Gear

TYPE 2, small reducing gear manufactured by Winfield H. Smith, Springville, Erie Co., N. Y., has been improved, as have the Nos. 4A, 5 and 8. The Type 2 reducer, shown in the accompanying illustration, retains the same center distances, shaft sizes and shaft extensions as the former model. This unit is equipped with bronze-bushed bearings for the high-speed shaft. The gear case provides for a greater oil capacity and is more rigid in construction than the former model. A screw plug at the top of the case provides for filling the chamber. Gear reduction of 48:1 or 30:1 can be had. The unit is regularly equipped with a 4-in. grooved pulley on the drive shaft and four-step grooved pulleys of 1, 1½, 2 and 2½ in. diameter on the driven shaft.

Spraco Lobster Claw Attachment

SPRAY painting has its application widened by means of the Lobster Claw Attachment shown in the accompanying illustration, which enables the spray operator, according to the manufacturer, to include every line within the architectural and industrial finishing fields, as this little auxiliary makes possible the cutting-in of trim on windows, doors, moldings, wall fixtures, and also the cutting between ceilings and walls, baseboards and floors, and other applications. This device is announced by the Spray Painting and Finishing Co., 60 High St., Boston.

Portable paint spraying equipment is of particular interest to the plant engineer as it supplies a speedy, easy, and economical method of painting buildings and other stationary objects.

A coverage of 4,000 to 5,000 sq. ft. can be obtained in an 8-hr. day, it is stated, while as much as 10,000 sq. ft. is often painted on large, free surfaces as compared with a range of 700 to 1,100 sq. ft. by the hand method. As a matter of average experience, spray painting uses approximately the same amount of paint but saves from 60 to 80 per cent of the labor cost.

Direct-Current Motor

A NEW line of 40-deg.-rating d.-c. motors, Type "NA," has been developed by The Louis Allis Co., Milwaukee, Wis. The new line of motors is interchangeable, rating for rating, in all essential dimensions with the Louis Allis polyphase motors. It is said that in this new line improved design and ventilation insure uniform cooling throughout the windings. The bearing chamber is designed to hold an extra quantity of oil. Bearing inspection is made through a removable cover, which, while permitting easy inspection, gives in effect a dust-tight bearing chamber. Elimination of oil trouble is claimed by virtue of a new design incorporated in the bearing.

Smoke Detector and Fire Extinguisher

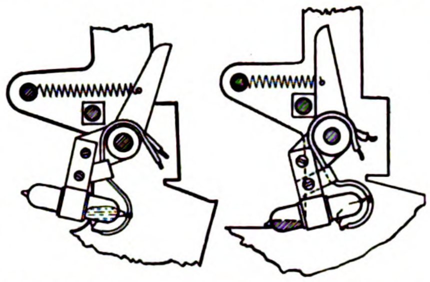
EQUIPMENT for indicating or detecting smoke and provision for the extinguishing of fires in enclosed or semi-enclosed electrical or other equipment is announced by Walter Kidde & Co., Inc., 140 Cedar St., New York City. The Rich system of smoke detection is employed. This makes use of a beam of light from a lamp, and a mirror. As long as the air in a machine or compartment remains clear the beam of light from the lamp remains invisible to the operator looking into the mirror. However, as soon as the air contains smoke particles a strong beam of light is observed. When smoke is thus indicated to the operator provision is made whereby he can, by the Lux system of fire extinguishing, release pure, dry carbon dioxide under pressure from steel cylinders, to smother the fire. It is stated that a single battery of cylinders can be connected up to protect any number of machines and compartments. The control for the release of the gas may be electrical or manual or both and be placed where desired.

This combination system is used to indicate over-heating sufficient to cause smoke, particularly in enclosed machines with ventilating systems, before a fire occurs. It is claimed that the Lux system of extinguishing fires may be used in transformer and oil switch rooms and in other similar places, as electrical fires may be extinguished in "live" equipment without damage and without removing the power from the circuit.

This system of detecting and extinguishing fires may also be used, it is stated, for protecting paint rooms, paint spray booths or other places where highly flammable oils or liquids are used. It may also be used for protecting wood pulverizers and other enclosed machinery of this general type.

Mercury Contact Switch on Pyrometer Recorder

A MERCURY contact switch which has been developed by Charles Engelhard, 33 Church St., New York City, to decrease electrical contact troubles in connection with pyrometer recorders is shown in the accompanying sketch.



This consists of a small glass tube containing mercury, a minute quantity of oil and an inert gas. Platinum electrodes pass through and are sealed in the glass tube. In the position shown at the left, the mercury makes contact with both of the electrodes and thus completes the circuit. Where the tube is tilted slightly to the position shown at the right, the mercury flows away from the terminals to the other end of the tube and breaks the circuit. A separate mercury switch is used for each pyrometer circuit and the required number of contacts are mounted side by side within the recorder case. The resistance, it is stated, is from 0.003 to 0.004 ohms. These mercury switches are said to be fume- and dust-proof and are designed for use in connection with electric resistance thermometers and thermo-couples, where extremely high precision is required.

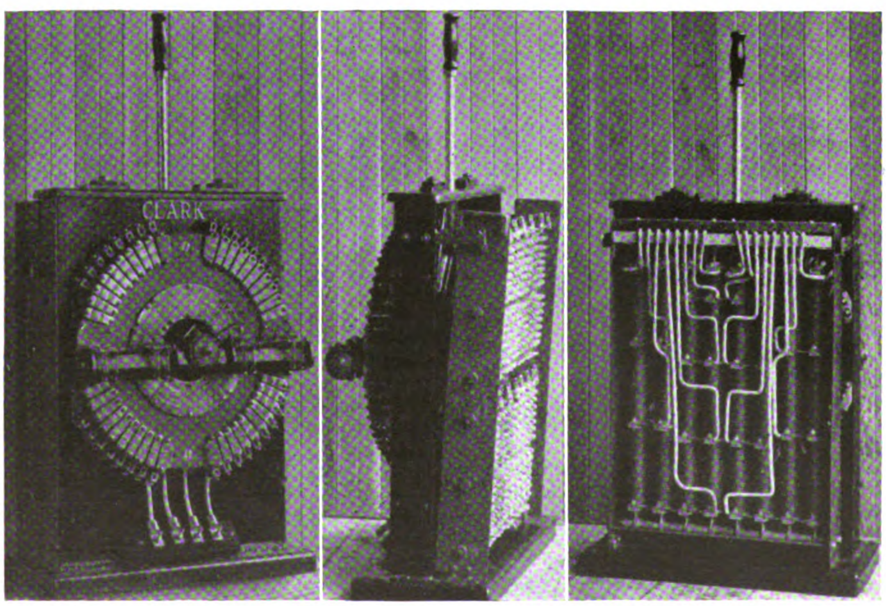
Manual D. C. Controller

ANNOUNCEMENT is made by The Clark Controller Company, Cleveland, Ohio, of a new, improved, face-plate-type, manual controller which, it is said, has been built for heavy-duty service, and is suitable for overhead traveling cranes, charging machines, mill tables, or any application where reversing of the motor is necessary and where hand operation is suitable. The frame of the controller, including the top and the base, is of heavy, pressed-steel plate.

The shaft which carried the contact arm rotates in a radial-thrust ball bearing near one end of the shaft and a graphite bronze bushing near the other end of the shaft. A magnetic blowout feature is provided in both sizes of controllers, which cover a range from 1 to 50 hp. at 230 volts and proportional ranges in other voltages.

Resistors of special alloy steel, which has been drawn or rolled—not cast—are used. The accompanying illustrations show (left) the No. 2 Clark manual controller, Type F, Form R; a disassembled view (center) shows the Type E M B resistor and the ease of removing or replacing the resistor filling. The view at the right shows the back of this controller with a Monitor Edgewound resistor.

Controllers of the same general type for a.c., three-phase, slip-ring motors are also manufactured.



Panelboard for Industrial Use

NEW lines of industrial panelboards for the control of lighting systems in offices and factories have recently been announced by the Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. These panelboards are made in sizes supplying from 4 to 32 circuits and in capacities ranging from 30 to 100 amp.

The new panelboards are constructed with two doors, one within the other. The smaller door, giving access to the switch compartment, has a snap catch and may be opened by anyone. The larger door, opening into the fuses, is equipped with a Yale lock so that only authorized persons may open it.

Both types of panelboards are built up in unit construction, with eight single-pole or double-pole switches. When single-pole switches are used the switch unit consists of two single-pole switches built on a composition base. With double-pole switches, a unit consists of one double-pole switch on a

base of the same material. These units may be easily removed from the front of the panelboard, which makes any necessary inspection and replacement easy, according to the statement of the manufacturer.

The cabinet fronts of these panelboards are equipped with the Westinghouse standard trim clamp for mounting the trim on the box. This clamp permits easy adjustment of the panelboard trim when the box has been set up out of plumb. The trim clamp allows adjustments up to ¾ in. in depth and laterally.

Oil Burner and Preheater

IN WELDING castings, preheating is oftentimes necessary to neutralize expansion and contraction strains, or to effect economy of gases. Without preheating, complicated castings are liable to develop new breaks at points remote from the weld after the weld itself has been successfully completed. The Milburn oil burner and preheater, which is primarily designed for this work is of the atomizing type and, it is stated, utilizes the cheapest grades of crude, fuel, kerosene oil or distillate, and compressed air under pressures varying from 50 to 100 lb.

The air-supply line furnishes a direct flow to the burner, and also maintains a similar pressure in the oil storage tank. Immediately upon opening the valves, the gas at the burner can be ignited.

Improved Resistance Starter

PRIMARY resistance starters, manufactured by the General Electric Co., Schenectady, N. Y., for squirrel-cage, induction motors, bearing the designation CR-7056-D-1, have been superseded by two improved types, the CR-7056-D-3, which is produced in sizes for use on motors up to 25 hp., and the CR-7056-D-4 for motors of 25 to 50 hp. The former has arc barriers and the latter is equipped with magnetic blowouts and arc chutes which permit it to handle safely the larger motor currents.

Both starters have an improved magnetic time interlock. The operating spring now works by compression instead of tension. The interlock can thus be adjusted more easily. The starting resistors have been redesigned to provide a greater capacity and to conform to Classification No. 16 of the Electric Power Club, which provides for 200 per cent full-load current or more on the first point for 15 sec. out of every four minutes.

The case for the D-3 starters opens from the top and is ventilated. It has two 1¼-in. knockouts both in the top and in the bottom, providing ample space for the power and the control wires.

The starter cover may be padlocked shut if desired. The D-4 case is larger than that of the D-3 to accommodate a larger resistor. This case opens on the side and can also be locked. It is provided with four 2-in. knockouts. Both models weigh 122 lb. and are arranged for wall mounting.

Trade Literature

you should know about

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Speed Reducers—Catalog 14 devotes 68 pages to descriptions and discussion of the various types and sizes of Philadelphia worm, spur and herringbone gear speed-reducer units. Dimensions and ratings of the different types are included.—Philadelphia Gear Works, Richmond & Tioga Sts., Philadelphia.

Oil Purifying—Bulletin 107 discusses the De Laval method of purifying transformer oil and switch oil by the application of centrifugal force. The operation of the centrifugal separator is illustrated by diagrams and a large number of installations are shown.—The De Laval Separator Co., 165 Broadway, New York City.

Chucks—Catalog 520 describes and illustrates various types and sizes of Westcott drill and lathe chucks.—Westcott Chuck Co., Oneida, N. Y.

Formica—A booklet entitled, "What Formica Is," describes how Formica is made, the different grades, and some of the numerous applications.—The Formica Insulation Co., 4633 Spring Grove Ave., Cincinnati, Ohio.

Portable Electric Saw—A circular describes and illustrates a number of uses of The Crowe Safety Saw, which is made in three sizes, to take 6-in., 8-in., and 12-in. blades.—The Crowe Mfg. Corp., 133 E. Third St., Cincinnati, Ohio.

Variable Speed Transmission—Catalog 20 describes the Lewellen variable speed transmissions and various types of manual and automatic controlling devices. This transmission unit permits operating a machine at a variable speed from a driving unit of fixed speed.—Lewellen Manufacturing Co., Columbus, Ind.

Flexible Couplings—A circular discusses the question of fatigue in couplings, with particular attention to the Fast flexible couplings.—The Bartlett-Hayward Co., Scott & McHenry Sts., Baltimore, Md.

Non-Metallic Gears — Publication C-1579-D discusses the computation of horsepower ratings of Micarta gears, with examples, and gives tables of the preferred pitch, the values of the constants used, gear data, and the horsepower ratings at various pitches. The qualities and advantages claimed for Micarta as a material for gears and pinions are well covered.—Westinghouse Electric & Manufacturing Co., Pittsburgh, Pa.

Brazing Outfit—A circular describes the Smith's No. 8 brazing outfit and the various tips and attachments.—Smith's Inventions, Inc., 2633 Fourth St., S. E., Minneapolis, Minn.

Speed Indicators—A circular shows the construction and use of a Hasler speed indicator for giving direct measurements of speeds either in r.p.m. or f.p.m.—Hasler-Tel Co., 461 Eighth Ave., New York City.

Short-Center Drive—Bulletin 1228 describes the Allis Texrope short-center drive which consists of sheaves on the driving and driven pulleys connected by small V-belts.—Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Ball Bearings—Catalog 25 covers general industrial application of Fafnir ball bearings and gives particular attention to their use in power transmission equipment. Catalog 26 contains, in addition to the general industrial applications, a large number of textile applications.—The Fafnir Bearing Co., New Britain, Conn.

Dead Ending Clamp—A circular describes the Screw Jack dead ending clamp for stranded cable, which is made in sizes suitable for standard cable from 4/O to 2,000,000 circ. mil, inclusive.—The Clark Controller Co., 1146 152nd St., Cleveland, Ohio.

Roller Bearings—Bulletin 1559 gives dimensions and load data on Hyatt roller bearings for industrial equipment and methods and data, including a table of factors for use under various service conditions, for determining the size of bearings for different loads.—Hyatt Roller Bearing Co., Harrison, N. J.

Ball-Bearing Tool Grinder—A circular describes the Bodine double-head, ball-bearing tool grinder operating at 3,400 r.p.m. These are made in two sizes, with ¼- and ½-hp. a.c. or d.c. motors.—The Bodine Electric Co., 2256 West Ohio St., Chicago, Ill.

Roller Chains and Sprockets—Catalog 57, 84 pages, covers the dimensions, rating and other data on Diamond chains, with a chart for their selection, and a discussion of their lubrication, installation and care.—Diamond Chain & Mfg. Co., Indianapolis, Ind.

Crane, Hoist and Mill Controllers—Bulletin 330 illustrates the construction, operation and characteristics of the Type F-2250 Allen-Bradley crane, hoist and mill controller.—Allen-Bradley Co., Milwaukee, Wis.

Pneumatic Tools—A 42-page, pocket size catalog describes the line of Thor piston and turbine pneumatic drills, hammers, foundry tools, and motor hoists.—Independent Pneumatic Tool Co., 600 W. Jackson Boulevard, Chicago.

Ball and Roller Bearing Motors—Bulletin 4000 illustrates and describes the bearing construction of d.c. and a.c. Reliance motors fitted with ball and roller bearings, and explains the various advantages claimed for them.—Reliance Electric & Engineering Co., 1051 Ivanhoe Road, Cleveland, Ohio.

Electric Melting Pot—A circular describes the Trent electric melting pot for continuous service. These pots are made in capacities of 10 to 1,500 lb. of lead, and are used for melting babbitt, solder, lead, tin, and other metals.—Harold E. Trent, 259-61 N. Lawrence St., Philadelphia, Pa.

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Founded 1882 as The Electrical Review

May, 1926

McGraw-Hill Publishing Co., Inc.
Chicago Ill.

Electric Steel Frames—Indestructible Rotor —Special Insulation Process—Volume Ventilation—and Tapered Roller Bearings

Allis-Chalmers motors equipped with Timken Tapered Roller Bearings add even more than anti-friction advantages to the impressive list of motor betterments credited to Allis-Chalmers.

Here are anti-friction bearings which improve starting and output characteristics. They carry *both* radial *and* thrust load so compactly that shortened shafts are possible to increase rigidity and conserve mounting space. And these motors serve equally well in any position, without any risk of running dry or soaking the windings.

The Timken-made electric steel in Timken Bearings puts finest possible material at the critical point in motor endurance. With finer steel, perfect lubrication, high thrust capacity, and nothing but rolling motion, the bearings in Timken-equipped Allis-Chalmers motors permanently maintain the closest gap. The only maintenance necessary, proved in widest actual use, is grease renewal perhaps only once a year—never more than every few months!

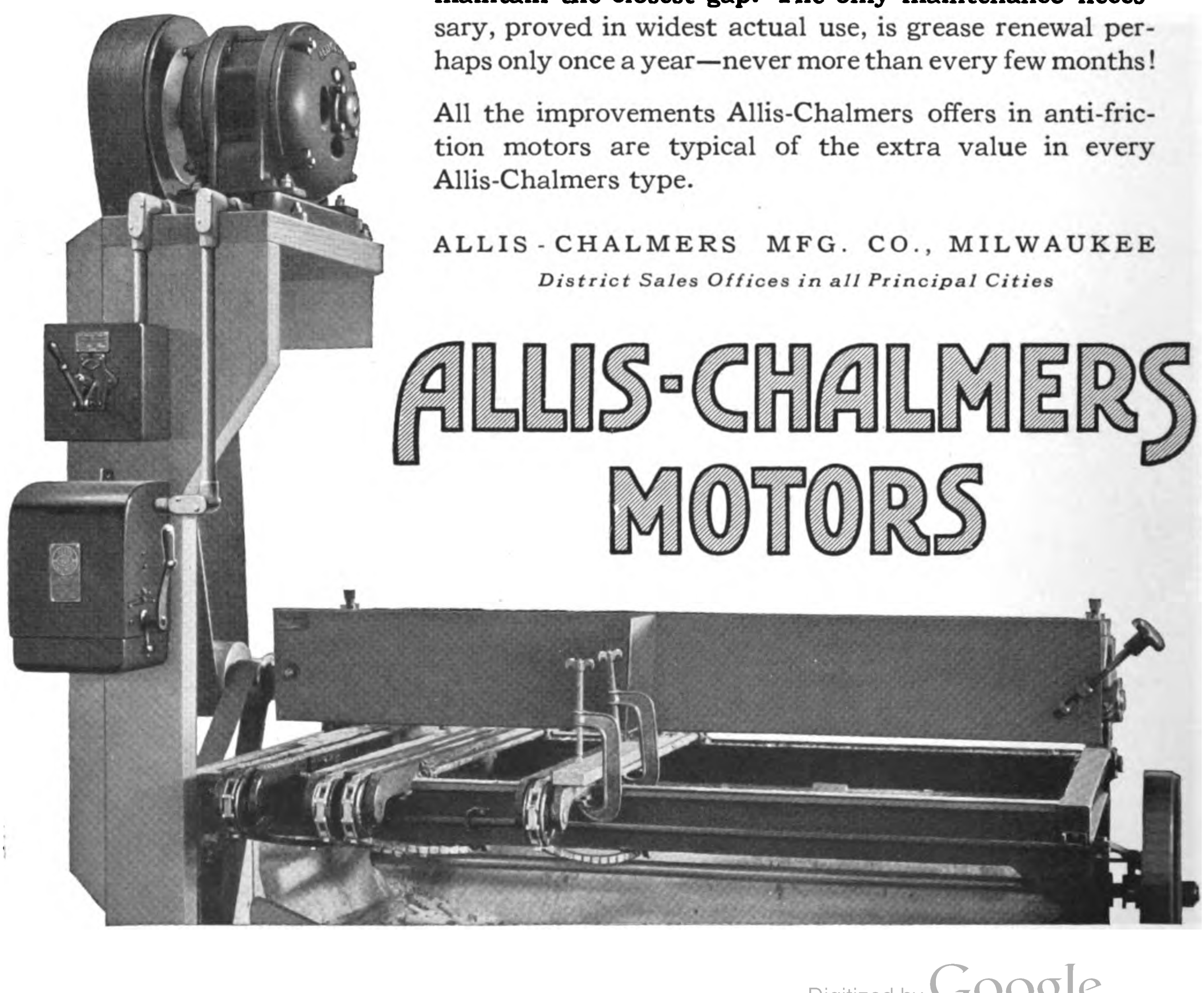
All the improvements Allis-Chalmers offers in anti-friction motors are typical of the extra value in every Allis-Chalmers type.

ALLIS-CHALMERS MFG. CO., MILWAUKEE

District Sales Offices in all Principal Cities

ALLIS-CHALMERS MOTORS

Type AR Allis-Chalmers Motor equipped with Timken Tapered Roller Bearings, belted to Mereen-Johnson Equalizer



INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Volume 84 Chicago, May, 1926 *Number 5*

Revamping Distribution System

of a 30-year old industrial plant so as to permit changing over from locally-generated direct current to purchased alternating-current power and light service, without stopping production

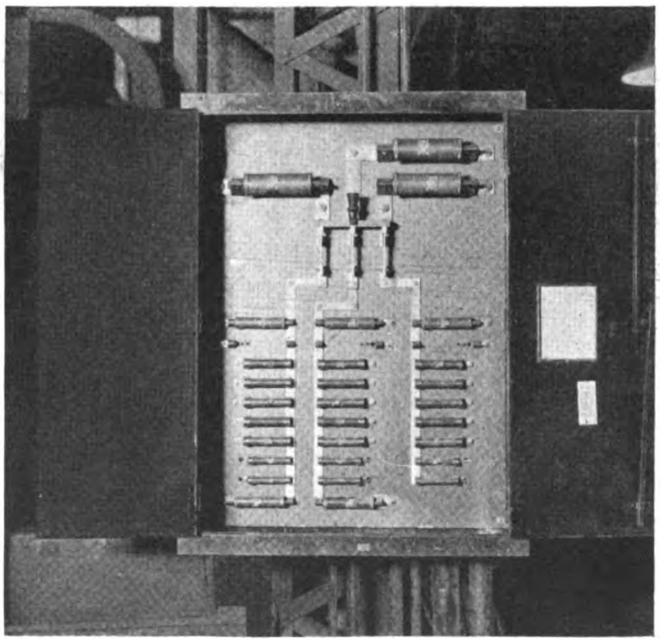
By J. C. NELLEGAR
Vice-President, H. W. Caldwell & Son Co., Division of Link-Belt Co., Chicago, Ill.

OUR plant had been operating uneventfully for about thirty years until last summer when we were suddenly faced with the problem of if and how we were to continue operation. We were generating our power at 220 volts, direct current, and distributing it on a two-wire system. Steam was supplied by three 150-hp. water-tube boilers, as old as the plant. Power was generated by a collection of engines and generators which had been added on as the plant and its power load increased. In addition, the large air compressor was steam driven.

We had been aware for several years that the generating plant and distribution system were out of date and would have to be replaced soon. For this reason we had made no purchases of new motors for some time, had carried a high repair expense on the old motors, and rented a motor whenever we needed one and had no spare.

Last summer, however, one of the boilers failed and had to be taken out of service, while another boiler was down for repairs to the brickwork. The one remaining boiler could not carry the load and it was several days before the others could be put back into service. During this time, the departments ran in staggered shifts on part time and we were afraid to operate near full load capacity even when the boilers were returned to service.

In the meantime, a firm of consulting engineers, W. J. Neely Company, Chicago, Ill., were engaged to make a survey of the plant in connection with our own engineers and those of the Link-Belt Company. On the basis of this survey eight alternative recommendations were made for the solution of our problems, with the detailed estimated cost of each. Five of these recommendations, which involved the entire rebuilding of the power generating plant, could not be given serious consideration because of the urgency of the situation. The other three recommendations were based on the use of purchased power. The first plan was to use rotary converters and retain the same d.c. motors and distribution system. The second plan was similar except that motor-generator sets were to be used. These plans were rejected because many of the motors were old and would soon have to be replaced anyway. Also, the maintenance cost of direct-current motors is high and alternating current service has many more advantages in plants of this type. The third plan, which was adopted, was to purchase power, put in an entirely new distribution system, and use alternating-current motors for all except a few drives. Steam is used for heating only and is now supplied by oil-burning boilers.



Power is distributed to the various machines in each department from cabinets such as these.
Conduit is run directly from the switchboard to these cabinets. The main circuit and each individual motor circuit are protected by Buss renewable fuses. Each circuit is numbered: the machines supplied by each circuit are listed on the card on the cabinet door.

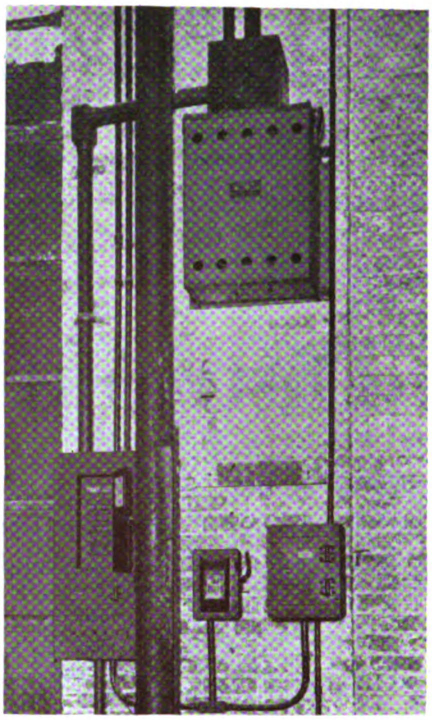
The plant consists of several buildings located closely together as may be seen from the drawing on page 205. Some of these are single-story buildings; the office building, however, is five stories high, a floor or two of which are devoted to manufacturing. The manufacture of elevating, conveying and power transmission machinery and other products required the power servicing of a foundry, machine shop, drives to rolls for making screw conveyors, a

sheet-metal shop, and other associated departments.

We are now operating on power which is delivered by the Commonwealth Edison Company at 12,000 volts, 60 cycles, three phase, and is stepped down by two 450-kva. General Electric transformers to 440 volts. The power goes through the 16-panel Westinghouse switchboard, shown below, and is then distributed throughout the plant as will be described later. Several direct-current motors were built into the machines, as for example on cranes, elevators, and on machine tools, and as it was not considered desirable at the present time to change them two Allis-Chalmers 100-kw., compound-wound, 250-volt, motor-generator sets driven by synchronous motors were installed to provide direct current. In addition to the present use, these motor-generator sets were necessary to supply direct current during the change-over period.

The best place to put the new switchboard, transformers, and other substation equipment was where the old boiler room stood but, as the plant had to continue in operation, the boilers could not be removed first. The procedure followed may be of interest to others who are considering a somewhat similar revamping problem.

The first consideration was to relieve the boilers by removing the demand for steam so that they could be taken out to give room for the new substation. The first piece of equipment erected was a cross-compound Worthington air compressor, driven by an Allis-Chalmers, 105-hp., synchronous motor. There was barely room to erect this in position in front of the stoker on one of the boilers. This compressor was supplied from a temporary circuit by back-feeding from a new alternating-current line which had been run into the new office building where the lighting and power load was easily changed over. This synchronous motor was excited from the old direct-current distribution system through a temporary connection. Although this is not the best operating practice, it was nesessary then.

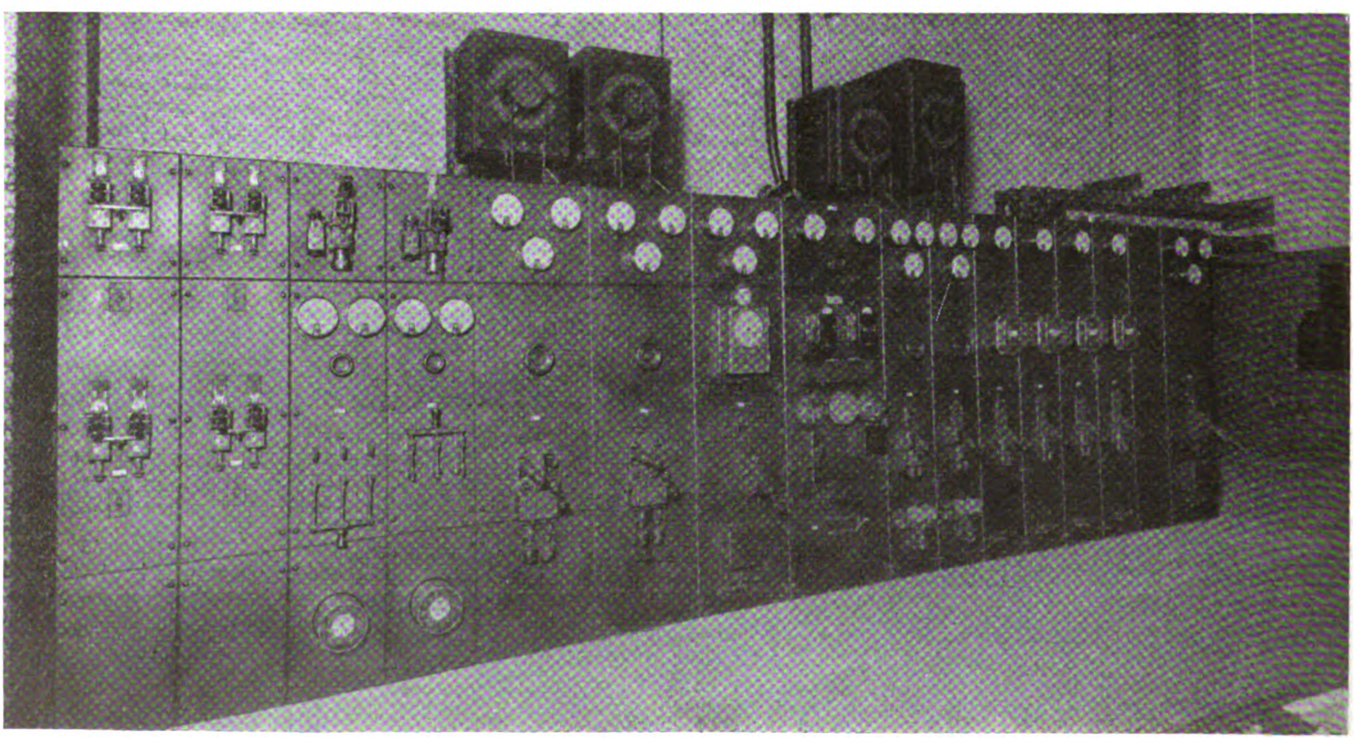


The transformers for the lighting circuits are placed at the distribution cabinets.

Current for lighting is taken from the distribution cabinets to the Packard Electric, dry-type, 440 220 110-volt transformers mounted on the wall as shown at the top of the illustration. The lighting circuits are protected by plug fuses. A Trumbull, type A, safety switch serves as a disconnect in the line. The lighting load is phase-balanced as shown in Table IV.

The distribution system at the Caldwell plant is controlled through this 16-panel switch board.

The various instruments on this board are listed in Table I. Power is delivered to the switchboard at 440 volts, 60 cycles, three phase, from two 450-kva., 12,000/440-volt transformers in the adjacent vault. The automatic Industrial Controller starter for the 20-kw. Allis-Chalmers, motor-generator exciter, which supplies the excitation for the synchronous motors on the air compressors, is on the wall at right.



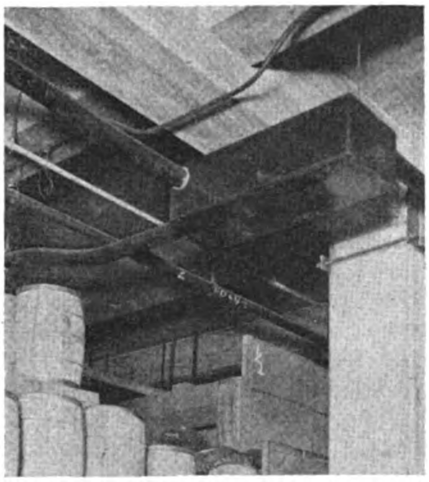
The motor-driven air compressor took a steam-driven air compressor out of service and so enabled two boilers to carry the load. The single-set boiler was then removed.

Two Allis-Chalmers, 100-kw., 250-volt, 1,200-r.p.m., compound-wound, motor-generator sets driven by synchronous motors were next installed, along with the direct-current section and compressor-control panels of the switchboard. The direct-current plant load was then cut over to the new board by picking up, cutting, and reconnecting the old feeders into the new board. The motor-generator

sets were supplied with power from a second temporary connection.

During this time the new conduit, feeder lines, cabinets and distribution system of the plant were being installed. It was necessary to operate one engine and generator for about two weeks until enough direct-current motors had been replaced by alternating-current motors to bring the direct-current power requirements down within the capacity of the motor-generator sets. The a.c. motors, as installed, were fed from temporary connections. Also a fire pump, driven by a 100-hp., slip-ring motor was put in.

We were then able to do without steam, as this was in the early fall and we do not use steam for process work. The battery of boilers was then removed, the two 450-kva., 12,000/440-volt transformers installed permanently, and the remainder of the switchboard built in. On the first Sunday after this work was completed, all circuits were phased out and we were then ready to cut over the distribution system from the temporary to the permanent installation as convenient. I could then rest easily; until the steam plant was shut down, I spent almost as much time in the power plant as in the office. Later, another 185-hp. synchronous-motor-driven air compressor, and the oil-burning heating plant were installed.



One of the junction boxes in the 3-in. conduit line which carries three 500,000-circ. mil. cables.

In no instance was it necessary to stop production to change over, as this work was carefully planned by the engineers and the electrical contractor, the Chicago Electrical Equipment Company, Chicago, Ill. Whenever necessary, the work of cutting over was done on overtime.

So far as possible all change-overs were made by first installing the new motor and placing it in position so that it could be belted or connected by chain to the new drive before the old d.c. motor was taken out of service. In this way, the cut-overs were made quickly with a comparatively small amount of overtime and without any interruption to production. On lineshafts and most of the machine drives, the new motor was located so that it could be connected up with a Link-Belt silent chain. This makes a short-center, compact drive. The installation of chain drives greatly simplified the cut-over problem in that the old drive could be operated while the new motor was being erected in position. The change over then consisted of removing the belt and putting on the chains in another location.

All of the a.c. motors are either of the squirrel-cage induction or slip-ring type. Where variable speed was not a factor, the plant was remotored with the type FTR, 60-cycle, 440-volt, General Electric, polyphase, double squirrel-cage induction motors. These motors have a high starting torque and may be started directly across the line without the use of special starting equipment. They are controlled by General Electric type CR-7006-D5 enclosed magnetic switches from momentary-contact, start-and-stop, push-button stations. Relays provide undervoltage protection against temporary failure of voltage. All of the G. E. starters up to 25 hp. are of the same type and size for standardization. The only change necessary is in the rating of the thermal relay, to fit the horsepower of the motor. The push buttons may be placed either at the switch or at the machine. A Westinghouse enclosed, externally-operated safety switch, type WK-60 is placed in the line ahead of the magnetic switch as a disconnect. The fuses for the motor circuits are mounted in the distribution cabinets.

Table I—Instruments on Switchboard at Caldwell Plant

Panels 1 and 2 (d.c. feeders)

2 400-amp., 250-volt, two-pole, two-coil Westinghouse type CL circuit breakers.
2 single-throw, two-pole, knife switches.

Panels 3 and 4 (100-kw. compound-wound generators in motor-generator sets)

1 500-amp., 250-volt, single-pole, Westinghouse type CK inverse time element, shunt trip, circuit breaker.
1 0 to 300 volts d.c., Westinghouse style No. 293403 voltmeter.
1 0 to 600 volts d.c., Westinghouse style No. CGZ-10486 ammeter and shunt.
1 Allis-Chalmers rheostat control.
1 600-amp., 250-volt, three-pole, single-throw, type A knife switch.
1 Sangamo two-wire, 250-volt, type D-5, 500 amp. watt-hour meter with shunt.

Panels 5 and 6 (150-hp., 440-volt, three-phase, synchronous motors)

1 Westinghouse a.-c. ammeter, 8.5 amp. coil, style No. CGZ-10436; 208-amp. division marked in red.
1 Westinghouse d.c. ammeter and shunt, style No. CGZ-10486; 20-amp. division marked in red.
1 Westinghouse three-phase power factor meter, style No. 363682A.
1 Allis-Chalmers rheostat control.
1 Motor starting and running oil circuit breaker, 300-amp., Westinghouse type QF with inverse time element overload and low-voltage trip.
1 Set of 300-amp., Westinghouse disconnects.

Panels 7 and 16 (450-kva., 12,000/440-volt, three-phase, 60-cycle transformers)

1 Westinghouse a.-c. ammeter, style No. CGZ-10436.
1 Three-phase Westinghouse power-factor meter, style No. 363682A.
1 Three-phase indicating wattmeter.
1 Bristol recording voltmeter for 24-hr. circular chart. (On Panel 7.)
1 8-in. Faraday Underdome, 110-volt, a.c. bell, fed from lighting transformer. (Panel 16.)
1 1,500-amp. Westinghouse type WB2 oil circuit breaker, inverse time element, overload relays and 24-volt, d.c. shunt trip.
1 Set of 1,500-amp. Westinghouse disconnects.

Panel 8 (20-kw. exciter and Commonwealth Edison meter panel)

1 A.c. voltmeter (440-volt bus), Westinghouse style No. CGZ-10436.
1 D.c. voltmeter, 0 to 300 volts, Westinghouse style 293403B.
1 Allis-Chalmers rheostat control.
1 100-amp., 250-volt, two-pole, double-throw type A knife switch.
2 G. E. polyphase watt-hour meters type O-6, Commonwealth Edison Co. metering.
2 G. E. demand meters.
1 G. E. instantaneous overload relay, type Q-6.

Panels 9 and 10 (105-hp. and 185-hp. synchronous motors on compressors)

Metering same as on panels 5 and 6.
1 Set of hand-operated Westinghouse disconnects for oil circuit breakers, style No. 296782:
200-amp. disconnect for panel 9.
300-amp. disconnect for panel 10.

Panels 11, 12, 13 and 14 (a.c. feeders)

1 Westinghouse a.c., 500-amp. ammeter, style No. 363836A.
Panel 14, 700-amp. ammeter.
1 Westinghouse type OA polyphase watt-hour meter.
1 Westinghouse 400-amp. oil circuit breaker, inverse time element overload relays.
1 Set of 400-amp. disconnects.
Panel 14 has 600-amp. circuit breakers and disconnects.

Panel 15 (a.c. feeder)

Blank, with 600-amp. capacity for future expansion.

Table II—Partial List of Materials Used

16,880 ft.	½-in. Buckeye conduit
6,620 ft.	¾-in. Buckeye conduit
4,000 ft.	1 -in. Buckeye conduit
3,180 ft.	1¼-in, Buckeye conduit
870 ft.	1½-in. Buckeye conduit
940 ft.	2 -in. Buckeye conduit
630 ft.	2½-in. Buckeye conduit
1,620 ft.	3 -in. Buckeye conduit
380 ft.	3½-in. Buckeye conduit
Habirshaw wire	
58,125 ft.	No. 14 R.C.S.B.
8,750 ft.	No. 12 R.C.S.B.
6,875 ft.	No. 10 R.C.S.B.
5,000 ft.	No. 8 R.C.S.B.
Stranded	
3,260 ft.	No. 6 R.C.S.B.
1,250 ft.	No. 4 R.C.S.B.
625 ft.	No. 3 R.C.S.B.
625 ft.	No. 2 R.C.S.B.
2,050 ft.	No. 1 R.C.S.B.
Cable	
800 ft.	No. 4/0 R.C.D.B.
492 ft.	No. 3/0 R.C.D.B.
1,250 ft.	No. 2/0 R.C.D.B.
398 ft.	No. 1/0 R.C.D.B.
142 ft.	700,000 circ. mil
3,624 ft.	500,000 circ. mil
1,125 ft.	400,000 circ. mil
R.C.L.C. cable	
785 ft.	500,000 circ. mil
510 ft.	400,000 circ. mil
500 ft.	350,000 circ. mil
350	Benjamin R.L.M. reflectors equipped with lamps furnished by Peerless-Brilliant Lamp Division
300	Bryant switches and receptacles
10	Packard dry-type transformers, 440-volt, single-phase primary; 110/220-volt secondary
600	Miscellaneous Unilet fittings
612	Miscellaneous 600-volt Buss renewable fuses
14	Power cabinets and panels, 4 to 12 circuits each
15	Wall-mounted lighting cabinets and panels, 8 to 20 circuits each
56	Special pull boxes
126	Type A, two- and three-pole 220/440-volt fused and unfused safety switches

All slip-ring motors are General Electric type MT, 440 volts, three phase, 60 cycles. These are controlled by G. E. type CR-3204-1500A secondary drum switches with interlocked primary contacts, G. E. type 7006 D5.

The distribution system centers around the switchboard. This is a 16-panel (including a spare panel) Westinghouse switchboard constructed of Johns-Manville Ebony Asbestos Wood in black marine finish. The framework is of angle iron and the panels rest on a channel-iron base, set in the concrete floor. In addition to the metering of the incoming power, each distribution panel is provided with a Westinghouse recording watt-hour meter as well as the necessary indicating volt- and ammeters. This gives the power consumption in all departments and permits charging each department with its proper power load. In some instances, two or more departments are supplied from the same panel, and so have one watt-hour meter in common. In such cases other meters are placed at the distribution cabinets in one or more of the departments. In this way the power consumption in each department may be obtained by subtraction. The power consumption also indicates the activity of a department. The instruments on the different panels of the main switchboard are listed in Table I.

The synchronous motors on the 100-kw. motor-generator sets are excited from their generators. The excitation for the synchronous motors on the air compressors is provided by a special 20-kw., motor-generator set located in the substation, but not shown in any of the illustrations. In addition, a double-throw, two-pole switch, shown on the lower portion of panel 8, permits connection to the d.c. bus fed from the 100-kw. motor-generator sets to obtain 250-volt excitation for the compressor motors in an emergency. The synchronous motors on the air compressors are equipped for automatic starting. This is done through a standard oil switch on the panel which is connected to a Westinghouse frequency relay that automatically closes the field circuit at a predetermined speed value.

All circuit breakers on the switchboard are equipped with an automatic alarm switch and a manual cutout to open the alarm circuit when the circuit breaker is left open. In addition, a signal system is provided which indicates any difficulty on the incoming 12,000-volt power lines. The 12,000-volt line switches and the 12,000-volt transformer switches are equipped with relays which open these switches in case of trouble. The line and transformer switches are equipped with contactors which operate drops in an annunciator and also blow a signal horn, both of which are located on the main switchboard. In case a high-voltage line or transformer switch opens, the operator's attention will be attracted by the horn. The switch which has opened is indicated by the drop on the annunciator. The trouble is then reported to the load dispatcher of the power company who will take immediate steps to correct the difficulty.

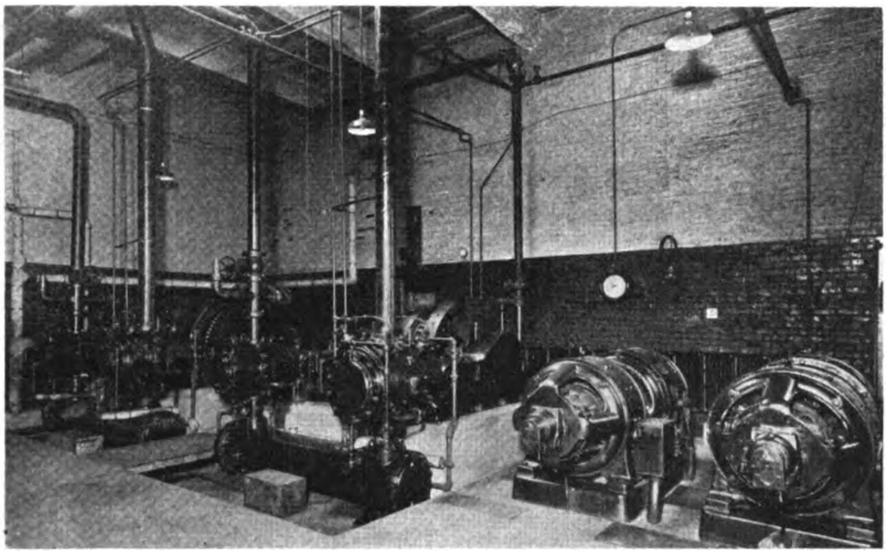
Every precaution has been taken to prevent interruption of the fire-pump service. To this end, the 100-hp. fire-pump motor has two sources of supply, one from each of the power transformer secondaries. Feeders are run directly from each transformer secondary to a three-pole, double-throw knife switch which is placed on the wall of the substation. The switch blades are connected to the fire-pump motor control in the pump room. The light and power supply for the substation and boiler room is controlled by another three-pole, double-throw switch in the same manner as is the pump-room service. The two switches, however, are located in the

Table III—List of A. C. Motors Used

Rated Hp.	Machine Driven	Type of Drive
	Warehouse	
5	Lineshaft	Belt
5	Lineshaft	Belt
15	Lineshaft	Chain
5	Lineshaft	Chain
10	Elevator	Belt
10	Elevator	Belt
	Foundry	
1	Dust arrester	Gear
15*	Heating fan	Chain
7.5	Exhaust fan	Chain
10	Lineshaft	Chain
20	Tumbler	Gear
15	Grinder	Gear
15	Grinder	Chain
7.5	Lineshaft	Chain
5	Lineshaft	Chain
50*	Cupola blower	Chain
15	Cupola blower	Belt
0.5	Lineshaft	Belt
5	Tumbler	Chain
	Sheet Metal Shop	
5	Punch press	Gear
15	Lineshaft	Chain
15	Lineshaft	Chain
2	Forge blowers	Chain
	Machine Shop	
10	Car puller	Built in
7.5	Press	Gear
15*	Heating fan	Chain
5	Drill press	Chain
10	Radial drill	Chain
10	Milling machine	Belt
15	Lineshaft	Chain
7.5	Lineshaft	Chain
7.5	Keyseater	Gear
20	Radial drill	Chain
20	Planer	Gear
15	Lineshaft	Chain
1	Power saw	Belt
15*	Heating fan	Chain
15	Pulley grinder	Belt
25	Pulley grinder	Gear
15	Lineshaft	Chain
10	Lineshaft	Chain
10	Boring mill	Belt
7.5	Lineshaft	Chain
20	Boring mill	Chain
10	Elevator	Belt
15	Lineshaft	Chain
5	Lathe	Belt
20	Lineshaft	Chain
	Conveyor Shop	
15*	Heating fan	Chain
8	Forge blower	Built in
40*	Hot press roll	Built in
7.5	Hammer	Belt
10	Lineshaft	Belt
50*	Hot roll	Built in
15	Fan	Belt
10*	Cold roll	Chain
75*	Cold roll	Chain
10	Lineshaft	Belt
15	Lineshaft	Belt
10	Lineshaft	Belt
5	Lineshaft	Belt
7.5	Punch press	Belt
20	Punch press	Belt
10	Lineshaft	Belt
0.5	Exhaust fan	Built in

All motors are 440-volt, three-phase, 60-cycle General Electric type FTR, double-squirrel-cage induction motors, except those marked in this table with an asterisk (*).

* Type MT, General Electric, 440-volt, three-phase, 60-cycle, slip-ring motors.



This equipment in the substation is placed opposite the switchboard.

Either of the two Allis-Chalmers 100-kw. motor-generator sets is capable of supplying enough direct current to operate all of the d. c. equipment which still remains in the plant. These sets, however, were required to supply direct current during the change-over, before all of the new a. c. equipment had been installed. The two Worthington, two-stage, cross-connected air compressors are driven by 105-hp (center) and 185-hp. (left) Allis-Chalmers, 440-volt, 60-cycle, three-phase, synchronous motors excited from a 20-kw. m. g. set.

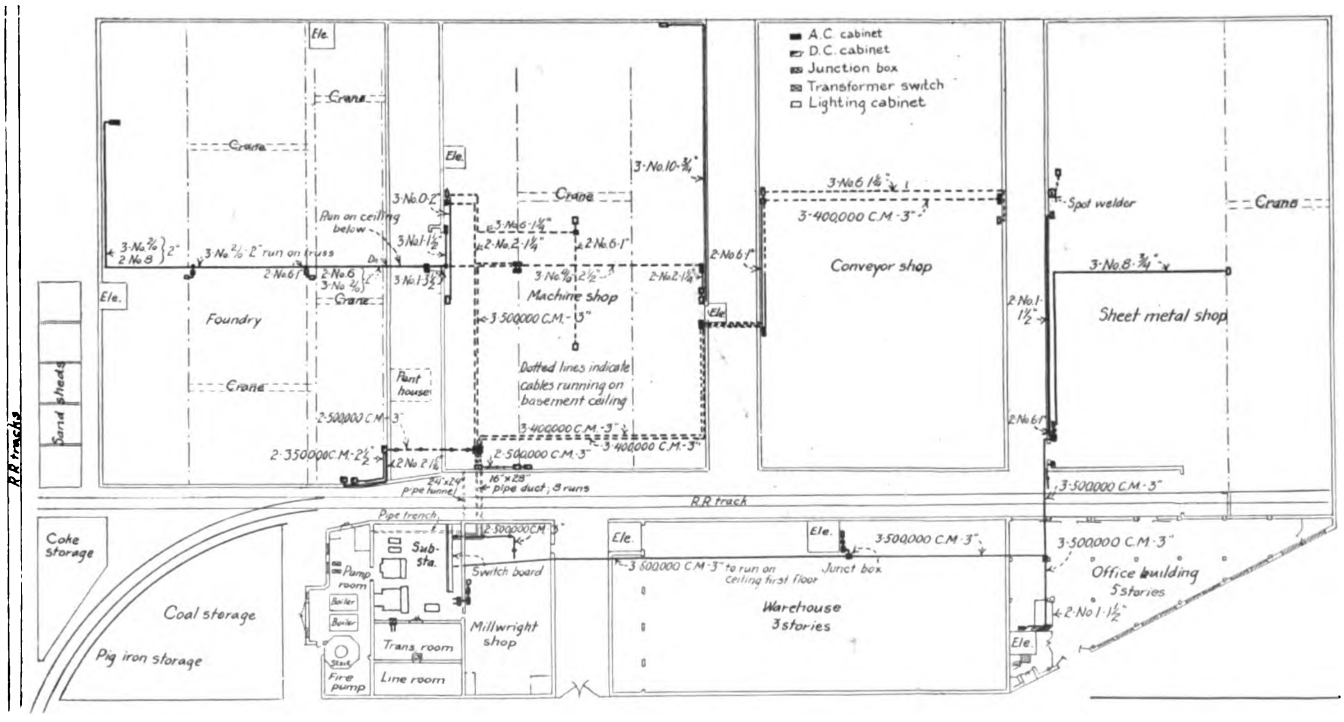
substation at a considerable distance apart and on different walls of the room, so that there will be less likelihood of confusing them.

The double-throw switches for each service are connected so that with both switches "up" they connect to the secondary of the same power transformer. Similarly, if both switches are "down," the connection is made to the other power transformer secondary. When both power transformers are in service, these switches can be thrown either both "up" or both "down," or one "up" and one "down." It is desirable, however, that both of them always be thrown in the same direction. Why this is so is probably best shown by analyzing the operating conditions. Suppose, for example, that both switches are thrown "up," that is, taking power from transformer No. 1. Assume that transformer No. 1 fails and is automatically taken out of service by the protective relays; the failure of transformer No. 1 would put out the substation lights and the operator would then transfer the station light and power to transformer No. 2 by throwing the service switch "down." The next move would be to throw the fire-pump service switch "down," or onto transformer No. 2, and thus restore the fire-pump service.

If the substation were operating with both switches "down," or on transformer No. 2, and transformer No. 2 should fail, the above cycle of operations would be repeated and service restored by throwing both switches "up" which would transfer the load to transformer No. 1.

The objection to operating with one switch "up" and the other "down" is as follows: Suppose the substation service switch is thrown "up," or on transformer No. 1 and the fire-pump service switch is "down," on transformer No. 2. In case transformer No. 2 fails and is automatically taken out of service, the substation light and power supply would not be interrupted because it is connected to transformer No. 1. The signal horn would blow and the operator would be busy notifying the load dispatcher and looking after the load on the switchboard. This presents the possibility of forgetting to throw the fire-pump service switch "up," and thus leave the plant without fire protection.

Power is distributed from the switchboard to the various departments, as already mentioned, by separate feeders in conduits extending from the various panels as indi-



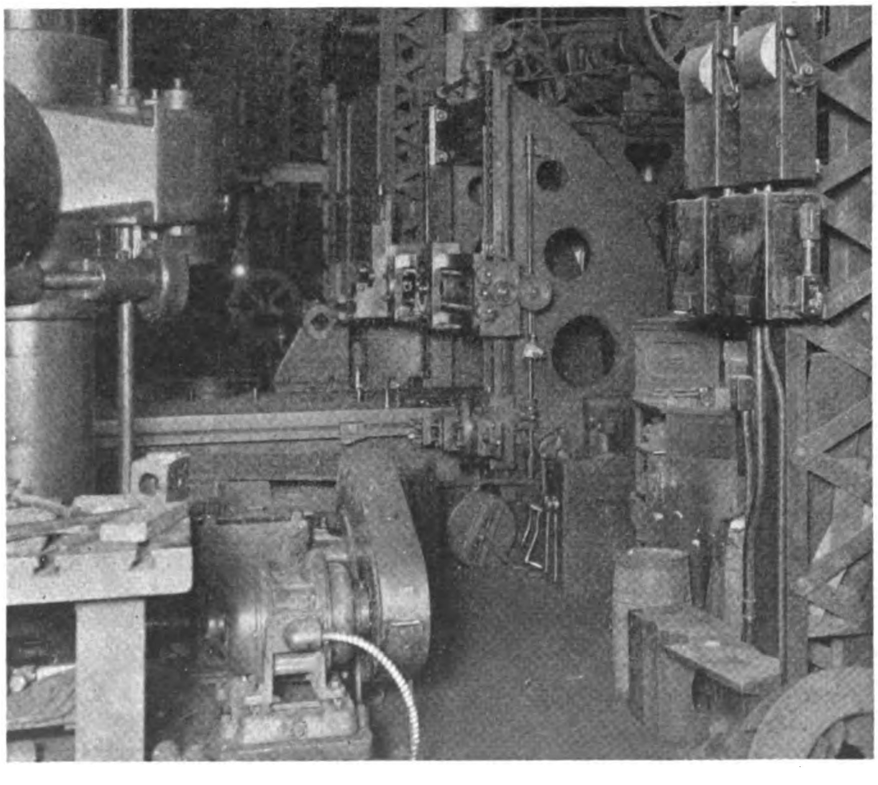
This shows the layout of the distribution system and the location of the power and lighting cabinets in the various departments.

cated. The feeders go down from the back of the switchboard into an 18-in. by 18-in. trench in the concrete floor, with a slate cover. In this trench there are three 3-in. conduits, each of which contains three 500,000-circ. mil, Habirshaw rubber-covered cables, and three 3-in. conduits, each containing three 400,000-circ. mil r.c. cables for the a.c. distribution system. Direct current is also distributed from the switchboard through two 3-in. conduits, each containing two 500,000-circ. mil, r.c. cables.

All but one feeder line crosses underneath the railroad tracks in a 16-in. by 28-in. pipe duct underground, which extends into the basement of the machine shop. The layout of the distribution system between the switchboard and the department cabinets is shown in the accompanying drawing on page 205.

Starting equipment and control for two of the motors.

All constant-speed motors are General Electric type F T R, 60-cycle 440-volt, polyphase, double-squirrel-cage induction motors which may be started directly across the line. The motors are controlled by start-and-stop push buttons (one may be seen on the side of the magnetic switch) which operate through General Electric type CR-7006-D5 enclosed magnetic switches. The safety switch placed above the magnetic switch is a Westinghouse type WK-60 which serves as a disconnect. From the control equipment the motor feeders are carried in conduit underneath the floor and brought up to the motor as shown, on the radial drill at the left, through flexible steel conduit. Many of the motors in this plant are connected to the driven machine by Link-Belt silent-chain drives.



The dotted lines indicate that the conduit runs are carried underneath the basement floor. The solid lines indicate conduit runs on the walls or ceilings. The locations of the various junction boxes and cabinets are also indicated.

Table IV—Phase Balancing of Lighting Load

Load	Service	Phase
37.5 kva.	Office building—Lighting	C-A
37.5 kva.	Sheet-metal shop—Welders	B-C
15 kva.	Sheet-metal shop—Lighting	A-B
15 kva.	Warehouse—Lighting	A-B
10 kva.	Foundry—Lighting	A-B
15 kva.	Foundry—Lighting	B-C
25 kva.	Machine shop—Lighting	C-A
25 kva.	Machine shop—Lighting	A-B
15 kva.	Conveyor shop—Lighting	B-C
5 kva.	Substation—Lighting	C-A

In the layout of this distribution system the substation and main feeder lines were designed for an ultimate capacity of practically twice our present requirements, which are now supplied by the two 450-kva. main transformers. The incoming line room and transformer vault were built to hold two 1,000-kva. transformers and the switchboard and distribution lines will care for the load when the time comes. By that time, the feeders between the distribution cabinets and the various machines will most likely require relocation and any necessary increases in the size of wire in the conduits from the cabinets to the machines can be made at that time. However, in no case is the wiring figured so closely that some increased load cannot be taken care of now.

Wherever possible, the conduit is exposed and supported by pipe straps on all runs. In all cases, where possible, the conduit was placed in long runs with the necessary pull boxes installed in the runs to facilitate pulling in the wire. One of the steel distribution cabinets is shown in an accompanying illustration. The amount of wire, conduit, fittings and other material and equipment used on the job is given in Table II. The total cost, including installation, of the equipment and distribution system was approximately $150,000.

There are in all about 85 alternating-current motors in this plant, varying in rating from ¼ hp. to 75 hp., with an aggregate rating of 950 hp. A partial list of the motors is given in Table III. This total does not include the four synchronous motors on the motor-generator sets or connected to the compressors and the 100-hp. fire-pump motor.

As stated before, it was considered desirable to continue the use of direct-current motors totaling about 300 hp. This was particularly true of the crane and elevator service where the motors are built into the equipment. In the case of the belted elevators, however, the d.c. motors were removed and high-resistance, squirrel-cage motors installed in their place.

Current for lighting the departments is stepped down by a 2:1 ratio transformer to 220/110 volts. In this way, the lighting load of each department is included in the power load of that department. These lighting service transformers are Packard Electric, 440/220/110-volt, single-phase, 60-cycle, dry type. To balance the system, all lighting transformers are connected across the primary phases as shown in Table IV. It will be noted that these are balanced off in groups of three, which leaves the 5-kva. lighting load in the substation as the only unbalanced load.

One of the interesting features of this installation is the fact that we are operating with a power factor of over 90 per cent. The power company penalizes its customers for a power factor below 85 per cent and gives a bonus for a power factor above 85 per cent. The high power factor in this plant is partially due, of course, to the synchronous motors on the air compressors and motor-generator sets. However, much of it

is due to the careful selection of the rating of the motors installed on the various drives. Ordinarily, the load on any motor may be obtained by connecting the proper indicating or recording instruments in the circuit. When studies were made on the old installation, we were operating at an absolute minimum of power requirements because of the danger which might result from loading up the steam plant. After making some tests it was soon seen that it would be impossible to get any accurate results in this way. It then became necessary to select the motors for the different drives largely on the basis of judgment and the experience of our operating engineer as to whether or not the old direct-current motor had been heavily loaded.

The induction motors selected will operate at a power factor of about 85 per cent when fully loaded. To take advantage of this high power factor when loaded, we selected for each drive a motor of such rating that it would be well loaded under general operating conditions, even though it might be slightly overloaded under maximum operating conditions, which would seldom last for a long period. Because the motors are well loaded they operate at a high power factor which, with the corrective effect of the synchronous motors, enables us to operate at 90 to 94 per cent power factor.

With the exception of a few minor changes, the work is all completed. One of the big savings we have noted is the drop in the maintenance expense from about $300 a month, which was the case when the old motors were in use, down to practically nothing. Perhaps the most important result, although it cannot be measured in any monetary value, is the relief which comes with the knowledge that there will be but little likelihood of interruptions in production through power failure.

Construction of Tracing Desk Lighted from Beneath

IT IS often necessary to trace a drawing or blueprint the lines of which, when covered with tracing paper or cloth, are almost invisible. Holding a drawing against the window does not tend toward accuracy or neatness. Often it is almost necessary to redraw to get lines heavy enough to trace.

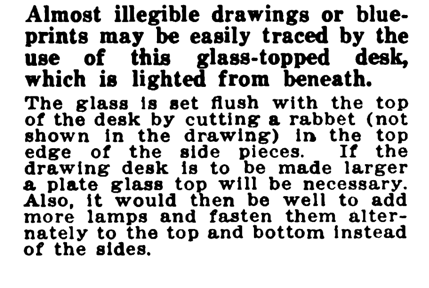
This difficulty has been overcome in our case by the use of the specially-lighted, glass-topped tracing desk shown in the accompanying sketch. Most gratifying results have been obtained and I thought perhaps others might have occasion to use it, as the desk is not only inexpensive, but easily made.

This desk consists of a wooden box, without top or bottom, made in the shape and dimensions shown on the drawing. The corners may be nailed, screwed or joined as desired. Wood at least ½ in. thick, and preferably heavier, should be used. Before fastening the corners together the top should be rabbeted to a depth equal to the thickness of the glass. Heavy window glass may be used, although plate glass is preferable.

The glass may be held in place with small, metal corner pieces, such as may be procured at any hardware store. These should be thin so as to interfere as little as possible with the drawing instruments. The left edge of the box may be trued up for the T-square. The lights and sockets are placed on the inside as shown and wired in parallel to the switch. The best distribution of the light is obtained by using the long type of frosted Mazda lamps, which are about 12 in. long by 1 in. in diameter. These can usually be obtained from local lamp dealers. The material required, in addition to the box and glass are two lamps, two porcelain sockets, a snap switch, and 8 or 10 ft. of two-strand flexible cord, fitted with a plug.

It is not necessary to place a bottom in the box although, if this desk is to be moved around much, it would probably be safer to do so as then there would be no possibility of placing the desk down on some unnoticed object and breaking the lamps. Better results may be obtained by painting the inside of the box white and, if no bottom is used, placing it on a sheet of white paper.

Bedford, Ind. AUGUST JEFFERS.



Almost illegible drawings or blueprints may be easily traced by the use of this glass-topped desk, which is lighted from beneath.

The glass is set flush with the top of the desk by cutting a rabbet (not shown in the drawing) in the top edge of the side pieces. If the drawing desk is to be made larger a plate glass top will be necessary. Also, it would then be well to add more lamps and fasten them alternately to the top and bottom instead of the sides.

Comment on "Power Drive Equipment for Air Compressors"

ON PAGE 15 of the January issue, in an article entitled "Power Drive Equipment for Air Compressors" by Gordon Fox, the following statement was made: "It is quite feasible to store a large supply of air in a receiver, the latter serving primarily to prevent frequent starting and stopping of the compressor due to leakage in connection with a piping system of small volume."

This sentence should have read, "It is *not* feasible to store a large supply of air in a receiver, the latter serving primarily to prevent too frequent starting and stopping of the compressor *caused by* leakage in connection with a piping system of small volume."—EDITORS.

Simple Kinks for Making Tight Joints

WHERE a plastic is needed for making a tight joint in a gasoline line, soap may be used. It has one great advantage in that it is available anywhere at all hours.

For making an oil-tight joint, use glycerine and litharge (oxide of lead). Mix this into a paste of the consistency of thick cream and use it between the metal surfaces or between metal and glass. A valuable property of this mixture is its elasticity for it may be put between surfaces that are subject to bending and it will not crack; this makes it very useful on parts that are subject to serious vibration.

Inserting rubber gaskets in recesses or pockets that are below the surface requires doubling them up so that they may be crowded through a narrow opening. When it is difficult to get these gaskets in place, much can be done by lubricating them with thick soapy water using, preferably, glycerine soap.

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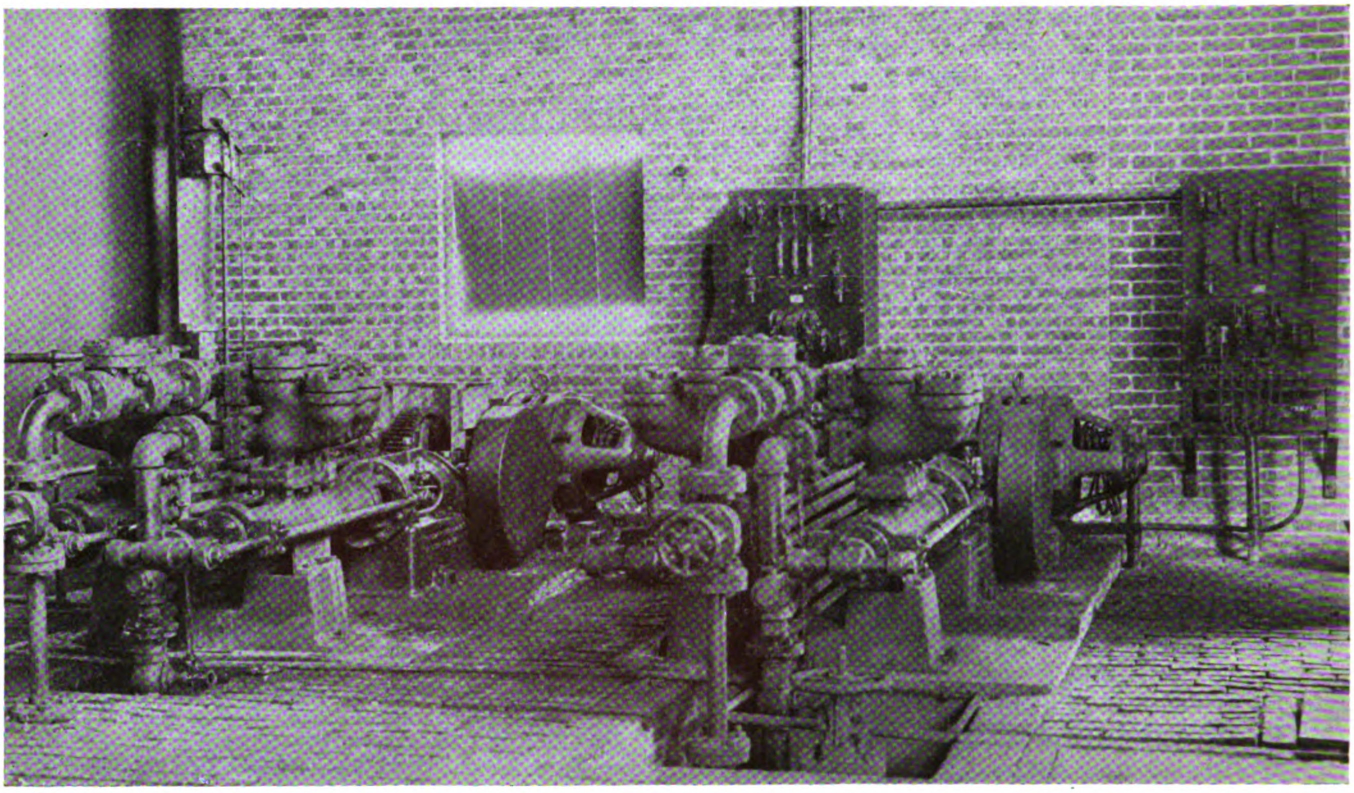


Fig. 1—These wound-rotor motors drive reciprocating pumps in a steel mill.

The two duplex, double-acting pumps deliver a pressure of 1,000 lb. per sq.in. to an accumulator shown at the extreme left. This high pressure is used as a power transmitting medium for certain steel mill equipment. Cutler-Hammer automatic control panels start and stop the motors, through the action of a float or limit switch shown at the left, mounted adjacent to the accumulator. Two gear reductions are used to get the proper speed.

Power Drive Equipment for Industrial Pumps

together with a discussion of their operating characteristics which affect the selection of the motor, control, and drive connection

By GORDON FOX
Electrical Engineer, Freyn Engineering Company, Chicago, Ill.

PUMPING of liquids is one of the most commonplace operations. The essence of pumping is power. It is said that more power is used for driving pumps than for any other kind of machine. Inasmuch as a very large number of pumps are motor-driven the requirements of pump drives are worthy of particular attention.

The two more common types are reciprocating pumps and centrifugal pumps. Rotary displacement pumps are less commonly used. These three types differ widely in many respects.

Reciprocating pumps work on the displacement principle. The action is positive, a fairly definite amount of liquid being displaced at each stroke of the plunger. These pumps are termed simplex, duplex, triplex, or quadruplex, according to the number of cylinders and pistons or plungers. In all pumps having more than one plunger the cranks are angularly displaced, which tends to equalize the liquid flow and power requirement. Pumps are termed single-acting if they displace liquid during one direction of travel only and are double-acting if the liquid is moved by the piston in each direction of travel. Fig. 1 shows a duplex, double-acting, high-pressure reciprocating pump, while a triplex pump installation is shown in Fig. 5.

The torque demand of a reciprocating pump is subject to periodic fluctuations due to varying crank effort. The magnitude of the pulsations is influenced by the number of cylinders. A flywheel is generally required to assist in smoothing out the torque demand.

Reciprocating pumps are normally slow-speed machines, the crankshafts usually running about 50 r.p.m. A gear reduction of about 4:1 is commonly inserted between the crankshaft and driven shift, which thus revolves about 200 r.p.m., as shown in Figs. 1 and 5. The motor may be connected to this driven shaft through a belt, gear, or silent-chain drive. In some instances synchronous motors are coupled directly to this shaft.

Reciprocating pumps have, in general, the following advantages: (1) Their efficiency, at high heads, is usually higher than that of centrifugal pumps. (2) They may be employed for higher heads than are obtainable with centrifugal pumps. (3) They are more simple where small quantities of liquid are required at high heads. (4) They give positive delivery and will usually start without priming.

The capacity of a reciprocating pump in gallons per minute may be found by the formula,

$Q=0.0034\times N\times d^2\times L\times K$, where
Q=capacity in gal. per min.
N=effective strokes per min.
d=piston diameter, in inches.
L=length of stroke in inches.

K=a constant, a measure of the slip or leakage. It varies from 0.7 to 0.97 depending on conditions. An average value of K is 0.95.

The power required by any pump may be expressed by the formula, $Hp. = (Q \times P) \div (1713 \times E)$, or $(Q \times H) \div (3960 \times E)$, where

Q=delivery in gal. per min.
P=pressure in lb. per sq. in.
H=total head in feet.
E=pump efficiency.

Average values of efficiencies for reciprocating pumps are given in Table I.

Very small pumps have lower efficiencies, as low as 25 per cent.

Reciprocating pumps displace a fairly definite volume of liquid at each stroke. The following conditions, therefore, apply to pumps of this type: (1) Reduction of head affects the volume or quantity delivered very little. (2) Reduction of head affects power required in direct proportion to the reduction. (3) Variation in speed when the pump is operating against constant head, causes the volume to vary in direct proportion. (4) Variation in speed, when operating against constant head, causes the power required to vary in direct proportion. The torque is fixed if head is constant.

A rotary pump displaces a definite quantity of fluid at each revolution of the pump rotor. This type of pump works under variable heads with a constant rate of discharge so long as the speed remains constant. Hence, if the speed is constant, the power required is directly proportional to the total head; or if the head is constant and the speed changed the power and rate of discharge vary directly as the speed.

The power requirement of the rotary pump is similar in all respects to that of the reciprocating pump and the power formula given on this page may be used. The relations of torque, power, speed, and volume are the same as with reciprocating pumps.

The rotary pump is similar to the positive displacement rotary blower. Quite commonly the rotors have three lobes. This type of pump is used only in small sizes and for moderate heads. For this service it enjoys the advantages of simplicity and absence of valves and packing. The pumping action of the rotary pump resembles that of the multiple cylinder reciprocating pump in its positive action, definite displacement, and somewhat pulsating delivery and torque. The speeds of rotary pumps are usually so low that motors of ordinary speed must be geared or belted to the pump shaft. Fig. 6 shows an installation of rotary pumps in which speed reducers are used to obtain the desired speed.

SELECTION of motors and auxiliary equipment for industrial applications is the subject of this series of articles by Gordon Fox. Previous articles of this series have appeared in the January and March issues. The accompanying article discusses the characteristics of reciprocating, rotary and centrifugal pumps, with reference to the application of motors to each type. A succeeding article will go into greater detail regarding the motors, control and auxiliary equipment best suited for pump applications.

Single-stage centrifugal pumps having a volute casing are used for low-head service up to about 200 ft. Multi-stage pumps are used for higher heads. Pumps of the latter type may be operated in series to develop heads up to 2,000 ft. Single-stage centrifugal pumps are illustrated in Fig. 8 while Fig. 7 shows an installation of multi-stage pumps.

Centrifugal pumps for moderate and high heads, and all multi-stage pumps, are inherently high-speed devices. Low-head pumps, particularly for large capacities, normally operate at moderate speeds and sometimes at low speeds. The tendency in general is toward high speeds as the impeller diameter and pump size are reduced thereby and the best efficiencies are usually attained. In the multi-stage pump the number of stages required may be less at a higher speed.

Centrifugal pumps have the following general advantages over other types of pumps:

(1) Simplicity, with minimum number of wearing parts.

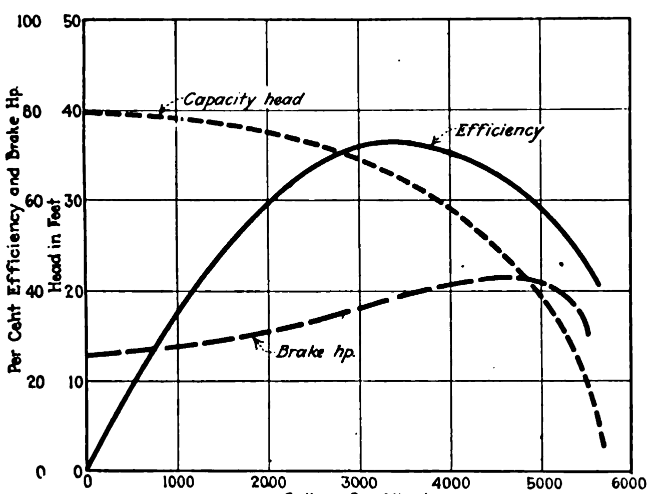
(2) Due to the high speeds used, they are relatively small, compact, and low in first cost.

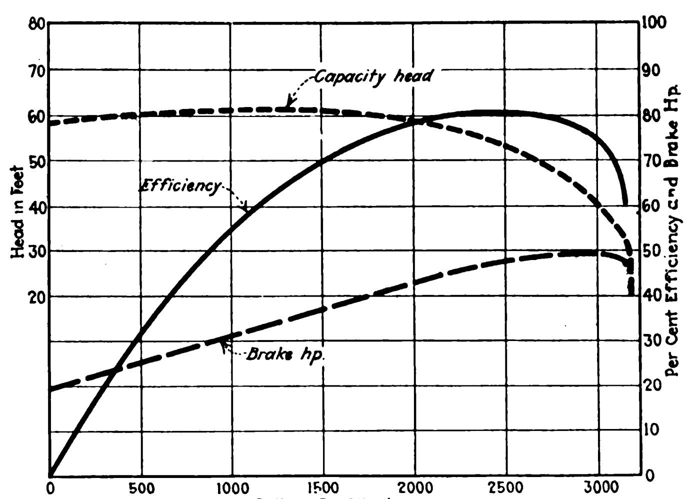
(3) They will handle dirty water, sewage, and water containing solids up to 40 per cent if designed especially for this requirement.

(4) They will not develop pressure beyond a predetermined value, in case flow is shut off. They may, therefore, be used on closed hydraulic systems to maintain a fixed pressure, churning during idle periods.

Figs. 2 and 3—Power required by centrifugal pump running at constant speed.

The power input required by a given pump varies with the number of gallons per minute delivered by the pump. The latter in turn depends upon the head pumped against. These relations are shown in the brake horsepower and capacity curves in both graphs. Fig. 2 on the left is for a pump having a steep capacity-head characteristic, while Fig. 3 is for a pump having a flat capacity-head characteristic.





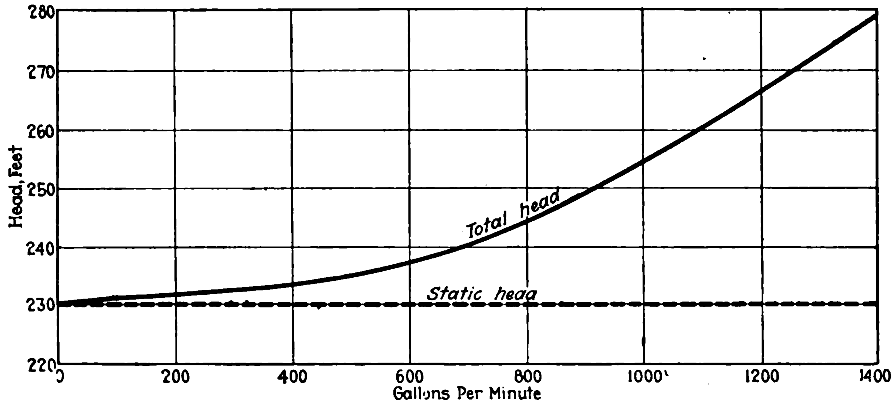


Fig. 4—This curve shows the total head required for various deliveries in gal. per min. on a given system.

The head of a system consists of the static head composed of suction lift and discharge head, the total of which is constant for a given system, as shown in the diagram. Superimposed on this is the friction head and velocity head which vary with the flow of liquid. The head delivered by a pump must equal the system head for the particular capacity or delivery required in order to maintain a condition of equilibrium.

(5) They deliver a steady flow at uniform pressure.

(6) They enable the use of high-speed, efficient motors of low first cost.

(7) They are more efficient than reciprocating pumps for low-head service.

(8) They will handle hot water to advantage.

The capacity of a centrifugal pump depends largely upon design details and cannot be determined by a general formula but must be obtained from the pump manufacturer's rating or curves.

The power required to drive a centrifugal pump can be determined by formulas given for reciprocating pumps on page 209.

Table II on page 211 gives approximate average values of efficiency for various centrifugal pumps when pumping clean water. Pumps having a high suction lift, such as condenser removal pumps and condensate pumps, have slightly lower efficiencies than those given in Table II.

As a general rule, head, speed, and power relations may be considered only by means of characteristic curves. The characteristic curves of a given pump show the efficiency, power input, and head developed, plotted as ordinates against volume or gal. per min. as abscissas. Fig. 2 shows the characteristic curves of a pump having steep capacity-head or *Q-H characteristic*, while Fig. 3 shows the characteristic curves of a pump having a flat capacity-head characteristic. The principal factor affecting the capacity-head characteristic of a centrifugal pump is the angle of the impeller blades at their tips. If the tips are radial or curved forward, in the direction of rotation, the head will be maintained as the delivery increases, as shown in Fig. 3. However, if the blades curve backward, the head will fall off with increase of delivery, as in Fig. 2.

The head of a system is composed of the following:

(1) Suction lift or intake head if the supply is above the pump. This may be somewhat variable in amount.

(2) Discharge head or elevation of the water column in the system above the pump. This may vary between limits.

The combination of (1) and (2) is commonly termed the static head.

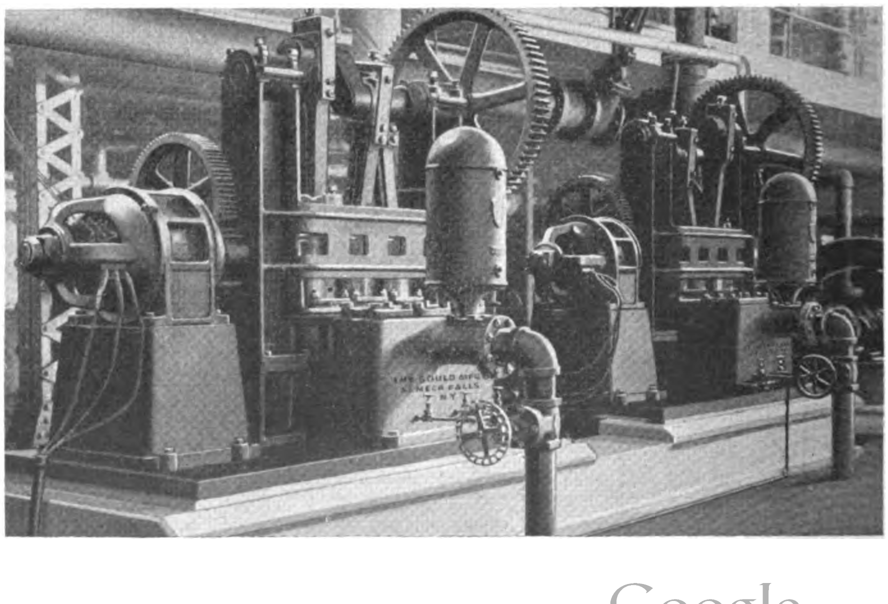
(3) Friction head, due to friction in pipes, fittings and valves. This is determined from tables of losses in pipe lines and fittings and varies with the volume, being proportional to the square of the volume and velocity.

(4) Velocity head $= V^2 \div 64.4$, where V is discharge velocity in ft. per sec. at discharge nozzle of pump.

The head of a system is commonly represented by a curve, as shown in Fig. 4, which shows the static head with no flow and the head increasing with the flow. The friction head in piping must not be neglected, lest the volume delivered by a centrifugal pump fall short of that desired or the motor driving a reciprocating pump be overloaded. The head developed by a pump must equal the head of the system on which it is working, to give a condition of equilibrium. Hence, if we superimpose the curve of system head upon the curve of the pump head, the point of intersection represents the condition of equilibrium and the corresponding volume gives the flow which will occur under the given condition. The corresponding horsepower also may be read from the power curve.

Fig. 5—Due to the heavy starting torque required, wound-rotor motors were selected for these triplex pumps.

These Gould pumps are installed at Central Mercedita of Yabucas, a sugar mill in Porto Rico.



The operating characteristics of centrifugal pumps differ radically from those of reciprocating pumps. The characteristics of centrifugal pumps follow these general rules:

(1) With constant speed, the volume will vary inversely as some function of the head, depending on the pump characteristic. Reduction of head causes great increase in volume delivered if the pump has a flat capacity-head curve and relatively small increase in volume if the pump has a steep capacity-head curve.

(2) With constant head applied, the volume will vary as some function of the pump speed depending on the pump characteristic. Variation in speed causes relatively great change in volume if the pump has a flat capacity-head curve and less change in volume if the pump has a steep capacity-head curve. If there is no static head, the volume varies directly with the speed.

(3) The head developed by a centrifugal pump is proportional to the square of its speed. The volume varies as the speed, if there is no static head. If there is a static head, the relation is not directly proportional.

(4) The power required by a centrifugal pump is a function of its vol-

ume and head and will vary materially as these vary. If there is no static head, the power required varies as the cube of the speed.

Although the centrifugal pump is similar in principle to the centrifugal fan, its performance is materially affected by the presence of static head which is independent of volume. The system head of a fan commonly varies as the square of the velocity. The system head of a pump commonly comprises the more or less fixed static head and the friction and discharge heads. The latter two components vary with the square of the velocity. If there is no static head, the pump and the fan are comparable.

It is universally true, within limits, that the capacity of a centrifugal pump varies directly with the speed and that the head developed varies with the square of the speed. When the system head is comprised partially of static head, however, the intersection or operating balance between pump head and system head occurs at a different point on the pump characteristic when the speed is changed, so that the actual resulting volume and head are not directly calculable.

To determine the effect of any changed conditions, new curves should be plotted and the corresponding balance point determined. If a change is made in the system head by throttling the discharge, the friction head will be increased so that the system head curve will bend more rapidly and a condition of equilibrium will occur at a lower volume and lesser power input. If the change is in the static head, as by a change in standpipe level, the system head curve will have its original curvature but will be higher or lower an amount corresponding to the change in static head. If the

Table I—Average Efficiency of Reciprocating Pumps

Head Pumped Against in Ft.	Efficiency Per Cent
50	47
100	60
150	68
200	73.5
300	78
500	81
700	82

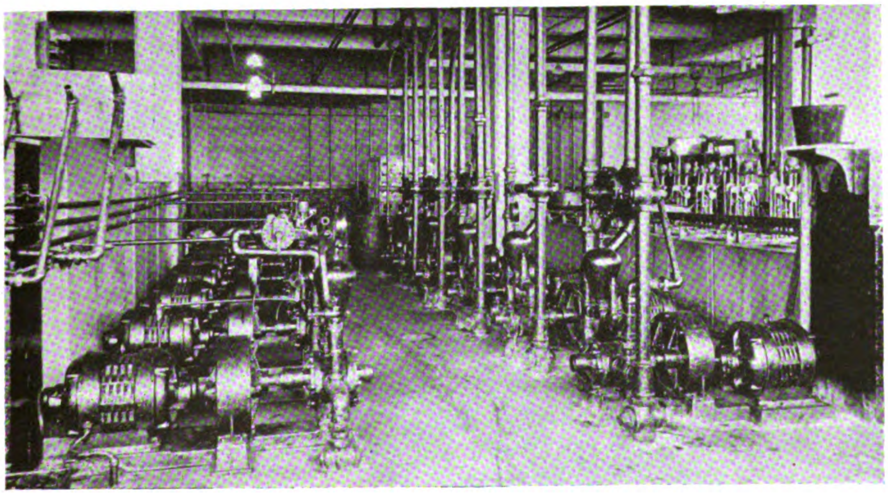
Table II—Average Efficiency of Centrifugal Pumps

Rating of Pump		Efficiency Per Cent
Gal. Per Min.	Head in Ft.	
100	10 to 50	25 to 50
500	10	50
	20	60
	50 up	65
1000	10	55
	20	63
	50 up	68
2000	10	58
	20	65
	50 up	70
4000	10	60
	20	65
	50 up	72
8000	10	63
	20	70
	50 up	76

static head will fluctuate between limits the two system head curves may be plotted corresponding to these limits and the corresponding points of balance limiting the operating range determined.

A centrifugal pump has high efficiencies over a portion of its possible operating range and low efficiencies over other portions. From a power consumption viewpoint it is important that a pump be selected which will normally operate within the efficient portion of its range. If the pump is to operate against a range of heads, as against a floating standpipe, the range of heads and the range of good pump efficiencies should coincide. Power losses due to inefficient pump operation may be of great magnitude as compared with motor losses. Pumps operated off-rating may be very inefficient. The over-all efficiency of pump and drive is the important result desired.

Fig. 6—Squirrel-cage motors driving through speed reducers are used on these rotary pumps.
This installation of Bowser rotary pumps is in the East Pittsburgh plant of the Westinghouse Electric & Manufacturing Company.



Volute pumps retain good efficiencies over a range of speeds if operated at favorable heads and volumes corresponding to the respective speeds. On high-pressure, multistage pumps, any departure from the most efficient speed is usually attended by considerable decrease in efficiency.

Pumps are driven by many types of motors, notably shunt and compound-wound motors of both constant- and adjustable-speed ratings, induction motors, brush-shifting commutator motors, and synchronous motors. The basis of motor selection involves the type of pump, nature of service, and electric system available.

The requirements of pump drives can nearly always be handled satisfactorily by some type of alternating-current motor. Unless direct current alone is available alternating current is ordinarily to be preferred both from the supply standpoint and for reasons of motor suitability.

The great majority of pumps operate at constant speed. For these drives the induction motor is eminently suited. Squirrel-cage motors, in sizes up to 500 hp., may be employed to drive centrifugal pumps but it is more common practice to use wound-rotor motors above 100 hp., or 200 hp., according to the nature of the supply system, so as to avoid objectionable starting current peaks. The induction motor with double squirrel-cage winding is now being adopted in some cases where it is desired to connect the motor directly across full voltage at start.

Starting conditions are more severe with reciprocating pumps, particularly when starting under load. Wound-rotor motors, as shown in Figs. 1 and 5, are commonly used for driving this type of pump in all but the smallest sizes.

Squirrel-cage induction motors and automatic-start motors are well suited for driving the smaller rotary pumps. Wound-rotor induction motors are desirable above 50 hp., primarily because of starting perform-

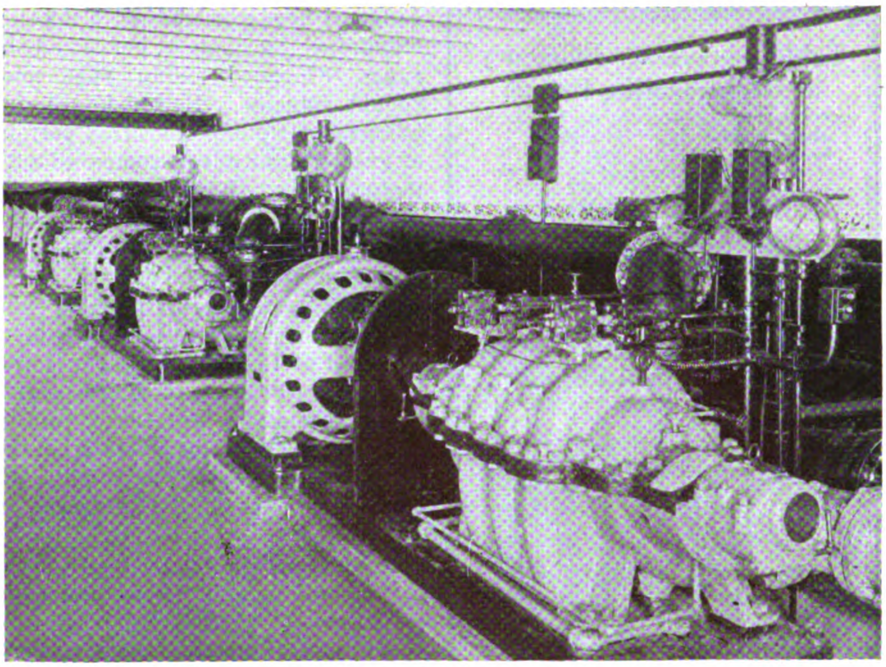


Fig. 7—Synchronous motors are used on these multi-stage centrifugal pumps.

These pumps are installed in a colliery of the Lehigh Valley Coal Co. The Allis-Chalmers centrifugal pumps are driven by Electric Machinery Co., coupled, bracket-type, synchronous motors rated at 300 hp., 1,200 r.p.m., 2,200 volts. The motors are remote controlled, a start-stop, push-button switch being located at the instrument board mounted over each motor. Cutler Hammer pressure and vacuum regulators are mounted on each instrument panel for controlling the operation of the pumps.

ance. In general the speeds of rotary pumps are rather low so that gear drive from a higher-speed motor is the most economical combination. Fig. 6 shows squirrel-cage motors connected to rotary pumps through speed reducers.

Special considerations as to the liquid pumped, such as gasoline, or benzine, may dictate the use of squirrel-cage motors and oil-immersed control equipment so as to avoid explosion and fire risk.

The synchronous motor is used to some extent for driving centrifugal pumps, notably in the larger sizes for pumps operating continuously. The high-speed synchronous motor has little advantage over the induction motor in the matter of efficiency. It has some advantage in the matter of power factor, but a high-speed induction motor driving a pump with a continuously maintained load, does not have a low power factor. In some instances synchronous motors are not available at the high speed most suitable for the pump. For large, low-speed pumps used for low and moderate heads, the synchronous motor is well adapted.

In applying a self-starting synchronous motor to a centrifugal pump drive, the pull-in torque is a main consideration. The starting torque is much less than the pull-in torque. The pump should be started with the discharge valve closed. The pull-in torque then required for churning will be about 50 to 60 per cent of full-load torque. Synchronous motors will develop this amount of torque without excessive current input. Starting conditions should be checked, however, whenever synchronous motors are applied to centrifugal pumps.

The synchronous motor offers one advantage in some instances, in that its torque decreases with decrease in voltage (with maintained excitation) less rapidly than that of the induction motor.

The 60-cycle system has a measure of advantage as related to centrifugal pump drives, as it offers a synchronous speed of 1,800 r.p.m. which is often more advantageous than the maximum of 1,500 r.p.m. available with 25 cycles. It also offers a greater variety of speeds.

Where direct current only is available the compound-wound motor is usually to be preferred for constant-speed pump drives. This type of motor is desirable for use with reciprocating pumps partly because of its better ability to meet the severe starting requirement. Shunt-wound motors are not well adapted to centrifugal pump drives as they are too sensitive to voltage fluctuation. The centrifugal pump, with its column of water, represents a load of high inertia. A compound-wound motor for centrifugal pump service should have only a moderate series field, approximately 10 per cent series ampere-turns. Such motors are available, having been specifically designed for this service.

In a concluding article, to be published in a succeeding issue, the application of the various types of motors to the different forms of pumps will be considered more in detail.

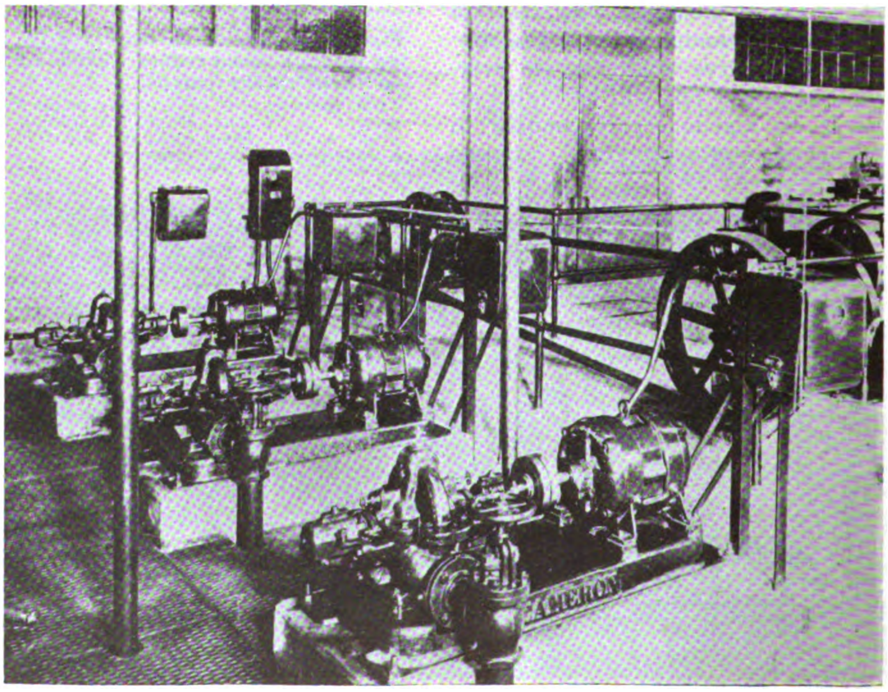


Fig. 8.—The characteristics of the squirrel-cage motor make it the ideal drive for centrifugal pumps of the smaller capacities.

Westinghouse squirrel-cage motors and compensators are used on these Cameron centrifugal pumps.

PREVIOUS ARTICLES in this series on lubrication, which have appeared in Industrial Engineer are "Using Oils and Greases for Industrial Lubrication" in the December, 1925, issue, and "Specifications for Oil and Grease Lubricants" in the March, 1926, issue. This present article will cover briefly a discussion of some of the methods and equipment used in the application of lubricants to lineshafts and machines. The lubrication of engines and turbines will not be included as this is an extensive subject in itself; the lubrication of motors will be covered in a later article.

Some types of

Equipment Used for Applying Lubricants

either continuously or intermittently to the different designs of bearings used on machines and lineshafts

Here a Zerk-Alemite compressor or grease gun with the low-pressure nozzle is being used to fill Hyatt hanger bearings.

By FRANK E. GOODING

Associate Editor, Industrial Engineer

METHODS of applying lubricants depend largely upon the provision for lubrication which was made by the manufacturer of the equipment and on the type of lubricant used. Even though much of the responsibility for the necessity of machine and drive maintenance is due to the use of the wrong type of lubricant or to its improper application, this problem is only beginning to receive its proper recognition and consideration in industrial plants.

The development of improved methods of lubricating industrial and power-transmission machinery has been along the lines of improved bearings, investigations to determine the proper lubricant for each class of work, and improved methods of applying it. In the old-time rough bearing, which did not fit closely on its shaft, the main problem was to apply sufficient lubricant frequently enough to maintain an oil film between the shaft and each bearing. Oil was applied periodically by means of a hand oiler; a bearing which was forgotten would often cause trouble later. Due to the fact that oil could run out of the open bearings so easily, the use of grease instead of oil became more common. The first improvements made in bearings were along the lines of making better bearing metal, investigations into the proper types of oil grooves, and bearings which fitted more closely on the shaft. More recently, when studying lubrication problems, attention has been directed towards the use of the proper lubricant for each type of service and operating condition and toward the improvement in methods of applying the lubricant.

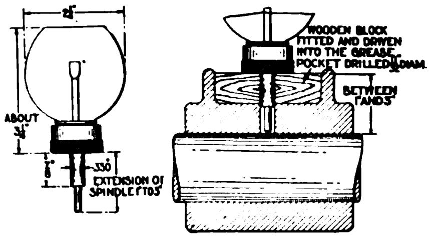
It was realized in these early studies that any interruption to the main power transmission service would interrupt an entire group of machines and so effort was directed toward the development of reliable power transmission bearings. As a result the ring, chain, wick and collar types of bearing oiling systems were developed. The bearing in each of these cases consists of a reservoir with one of the above devices for carrying and distributing the oil over the surface of the shaft. All of these bearings are well known and have been described in a previous article in the May, 1924, issue of INDUSTRIAL ENGINEER entitled, "Babbitt, Ball and Roller Hanger Bearings," and so will not be taken up at length here. The development of the automobile has been responsible for much of the investigation and study of lubrication problems. The results are being applied to the solution of industrial problems.

It is rather difficult to classify the equipment and methods of applying lubricants. This is largely due to the fact that greases and oils are both used as lubricants and also because of the wide variety and varying types of operating services which are found in industrial plants. Devices for applying lubricants, however, fall roughly into three gen-

eral classes: (1) Oil or grease containers located on the bearings; from these containers the lubricant drips or flows onto the shaft. (2) An oil reservoir around or near the bearing surface, together with some method of carrying the lubricant to the bearing surface; ball and roller bearings and bearings with the wick, ring, chain, collar, or splash type of lubrication belong in this class. (3) Pressure feed lubrication. This third class of lubricating equipment may be further subdivided into: (*a*) Continuous, such as where the pressure is applied by a pump or by a ratchet operated by a stroke or movement of the machine, or by the pressure of gravity from a storage tank placed overhead. (*b*) Intermittent, such as the stationary or portable grease guns which are operated at intervals by hand. (*c*) Circulating systems which differ from classification (*a*) in that the oil is circulated through the bearings, cleaned (in some cases), and recirculated.

The use of a closed container, such as an oil or a grease cup, is one of the most commonly used methods of applying lubricants. These cups are attached to the bearings and feed the lubricants through an opening or oil hole. These cups are of such a variety of types and are so well known that it is not necessary to go into extensive detail in explanation or illustration of them. Many types of oil cups can be regulated to feed a drop of oil regularly and are provided with sights so that their operation may be observed. Grease cups are frequently provided with springs behind a diaphragm which apply pressure to the grease.

Two of the important advantages of the closed oil or grease cups are that they require only periodic attention and that they also cover the oil hole so that dust cannot enter.



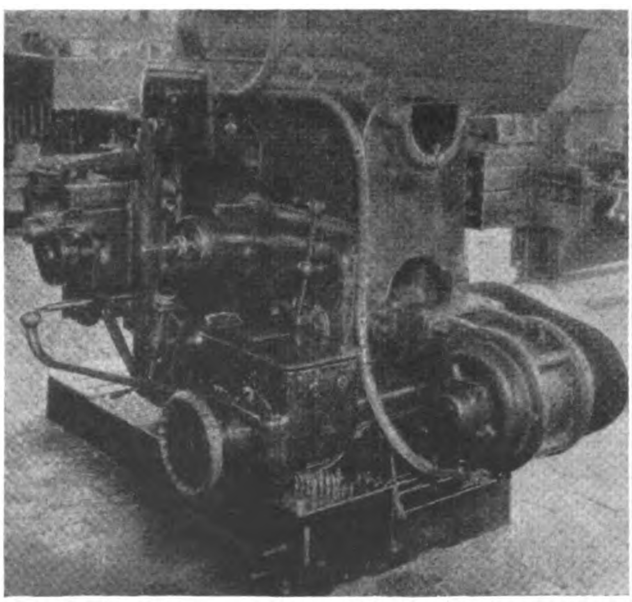
An example of a bottle oiler and one method of application.

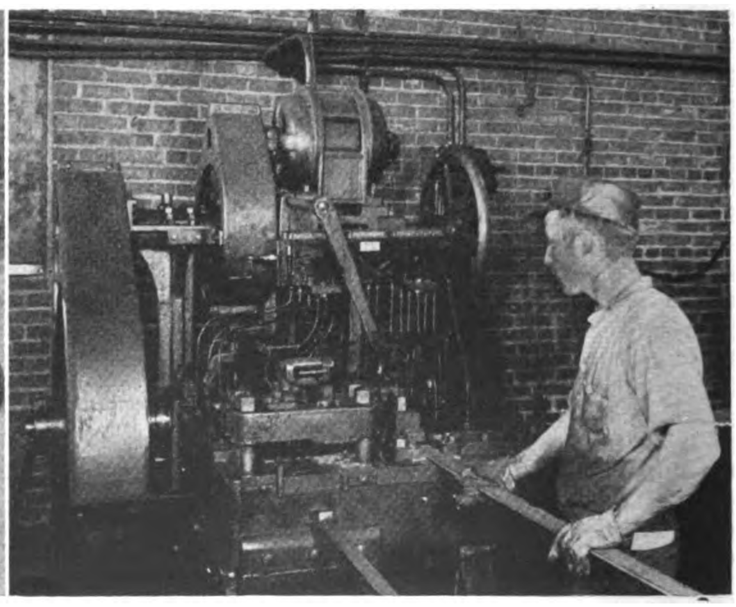
The description of this oiler is given in the text. The projecting sleeve fits into the oil hole and the spindle touches the shaft. The illustration at the right shows the application of a bottle oiler to the grease pocket of an old bearing.

In very dusty locations, however, care must be exercised in the filling of these containers, particularly grease cups, so that dust and dirt do not get into the grease and find their way into the bearings. On some machines, particularly in those industries in which dust is not created to any extent in the process or operation, oil holes are found in considerable number. However, the tendency in lubrication practice is largely toward protecting these openings at least with some type of small cap which automatically keeps the opening closed. Manufacturers of a large proportion of the better class of machinery provide a more positive type of lubrication wherever possible. However, on many types of machines, particularly those used where the work requires only intermittent operation, oil cups have many advantages. All oilers of this type are filled by hand.

The rate of feed on sight-feed oilers is usually measured by the number of drops per minute. The general practice with these oilers is to feed the oil too rapidly; this gives the bearing too much oil which frequently causes as much trouble as too little oil. In practically all cases any excess of oil runs out, catches dust, and dirties up the machine. In addition, there is the cost of the unnecessary excess oil used. Pressure feeding grease cups usually have some method of regulating the flow of the grease and also of shutting it off when the bearing is idle, either by relieving the pressure, or by closing up the connection between the grease reservoir and the bearings, as shown in the accompanying illustration of a Chicago automatic spring compression grease cup. Cups of this general type will feed any non-liquid lubricant. The amount of lubricant in the cup is indicated by the height of the feed screw; the flow is regulated by the stopcock in the stem.

The bottle oiler, which is shown in the illustration on this page, is a





Two different types of positive-feed lubricating systems which are used in industrial plants.

The illustration at the left shows a Madison-Kipp lubricator (Madison-Kipp Corp., Madison, Wis.) which lubricates not only the bearings, but also the slide of a shaper. The oil feed adjustment is set so that one filling will last about a month. The amount of oil remaining in the lubricator, which is located at the lower corner of the machine, is indicated by an oil gage. The lubricator rocker arm is actuated from the crossfeed mechanism. The eye spring forming machine at the right is lubricated by a McCord lubricator (McCord Radiator & Manufacturing Co., Detroit, Mich.) which is located on the front of the machine and distributes the oil to the various bearing surfaces through a system of pipes which may be seen in the illustration.

simple oil container and provides an easy method of automatically applying the lubricant to a bearing. This oiler consists of three essential parts: A glass container or bottle of about 4-oz. capacity, a tight-fitting cap, and a spindle. The bottle has a short neck and a threaded ferrule on which the cap can be screwed. The cap is threaded to fit the ferrule on the bottle, and contains a washer which makes a tight joint on the neck of the bottle. This cap has a projecting sleeve which is drilled to permit free movement of the spindle. The spindle consists of a straight piece of round steel about 0.187 in. in diameter. One end is flattened and placed inside the bottle to prevent the spindle from dropping out. In use the bottle oiler is placed in an inverted position (with the cap down) and supported in the bearing so that the end of the spindle rests on the journal or shaft. Since the bottle oiler is inverted and air tight, except for the spindle clearance, oil cannot leak out unless air enters. When the shaft is stationary, no air enters the bottom and no oil is lost. When the shaft is in operation the spindle of the bottle oiler is given a motion so slight that it can scarcely be detected. This motion is sufficient, however, to result in a pumping action which causes air to enter and oil to leave the bottle at a very slow but uniform rate through the small clearance space between the spindle and sleeve. As the oil flows down the spindle to the shaft, it is distributed to the bearing surfaces and so builds up the oil films.

Small bearings up to about 6 in. in length, can generally be lubricated satisfactorily by a single oiler unless the shaft is over 3 in. in diameter.

Two bottle oilers will generally take care of any lubricating demand, on bearings up to 10 in. in length and on shafts under 6 in. diameter. On large shafts or long bearings three or more bottle oilers are frequently used. These general considerations, are of course, influenced by the load on the bearing and the speed of the shaft. Heavily loaded bearings, of course, require more lubrication than bearings which merely support the weight of the shaft. Also, slow-speed bearings reduce the activity of the spindle of the bottle oiler and therefore require a greater number of oilers than have been indicated in the general statement just given. Slow speed also causes poor oil distribution and so the oil should be applied in more places along the length of the shaft.

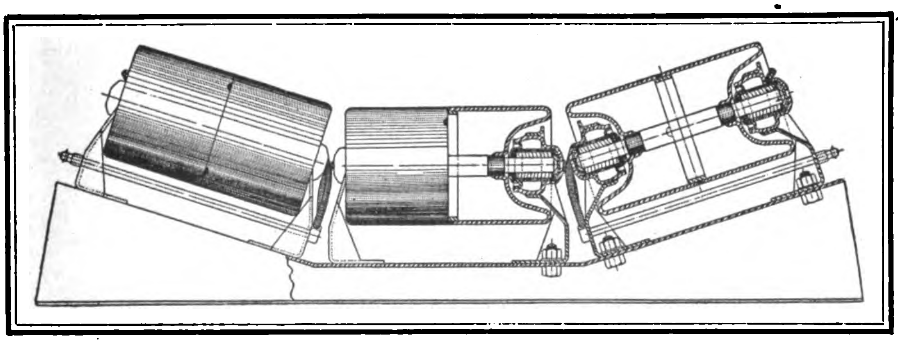
The Zerk-Alemite grease guns or compressors are filled through the pistol grip handle.

This type of gun is used for lubricating bearings or lubricant containers under pressure. This compressor has a different type of nozzle from that used in filling cavity bearings, such as on a roller-bearing lineshaft, as shown in the illustration at the head of this article. One turn of the crank on the filler tank loads the compressor. This tank weighs only 34 lb. and is carried around by the oiler to the different departments. Pressure is applied by placing the tip of the compressor against the fitting on the bearing and pushing down on the handle which forces a definite amount of grease into the bearing.

Bottle oilers may be used on the lubrication of almost any kind of horizontal bearings on shafting and machinery. The bottles, with spindles and caps attached, are filled in the oil room and interchanged at the machine. If this is done carefully, there is little opportunity for dust or dirt to enter the bearings. Bottle oilers are often used on bearings difficult of access while the machine is in operation. The oilers may be filled and inserted while the machine is idle and as they usually contain enough lubricant to last a week or more, even under continuous operation, the lubrication problem is cared for until the machine is shut down at the end of the week. This removes the necessity of shutting down for oiling, and also relieves the operator of the annoyance and danger of oiling inconveniently-located bearings while the machine is in operation.

When necessary these oilers may be mounted in an inclined position, providing the angle from the vertical does not exceed 30 deg. In such cases, the spindle rests squarely on the journal. A single example of the advantages of using a bottle oiler to regulate the flow of the oil, instead of relying on the haphazard method of oiling a bearing whenever the operator thinks about it, is taken from the experience with a blower located in a very dusty place. Under the former method of lubricating by hand, approximately a gallon of oil was used per day. Even then considerable trouble was experienced with hot bearings. The installation of bottle oilers and changing to an oil better adapted to such bearings resulted in a reduction in the bearing temperature and also reduced the quantity of oil used to about one pint in two weeks. One of the big advantages of an oiler of this type is that the feed is in proportion to the speed and cannot be increased because the operator thinks that the oil is feeding too slowly.

The second class of bearings considered consists of an oil reservoir around or under the bearings and some means whereby the oil is carried up to the bearing surface. Ball and roller bearings which are surrounded by oil or grease, are bearings of this type. The numerous



Here a three-pulley conveyor idler equipped with Hyatt bearings is greased by the pressure system of lubrication. Flexible hose connects with the tubes, carrying the lubricant to the four bearings at the center of the stand.

types of bearings which use rings, chains, collars or wicks to carry the oil to the bearing surface are also included in this classification. Among the big advantages of these bearings is that they require only infrequent attention and filling, usually at less frequent periods than the types of bearings included in the first classification. Among the disadvantages, however, are the inability to see that the oil-carrying device is in operation and also that it is difficult to see just how much oil is in the reservoir with the resultant possibility of under-filling, or over-filling. Bearings of this type are, however, very widely used and operate satisfactorily with a reasonable amount of care and attention.

Probably the larger proportion of lineshaft bearings come under this classification, including, of course, the ball and roller lineshaft hanger bearings.

Bearings in which the lubrication is obtained by means of an oil bath or splash system also fall under this second classification. The tendency in gear lubrication seems to be towards using the bath or splash system for lubricating gears and worms, even though they may be traveling at a comparatively low rate of speed. This gives a positive application of the lubricant to the wearing surfaces and is considerable of a contrast to the older method of applying a thick lubricant to the surfaces at irregular periods. On large and high-speed gear trains, such as are used in steel mills and on turbine reduction gears of large size, the tendency is towards the use of a circulating system in addition to the bath.

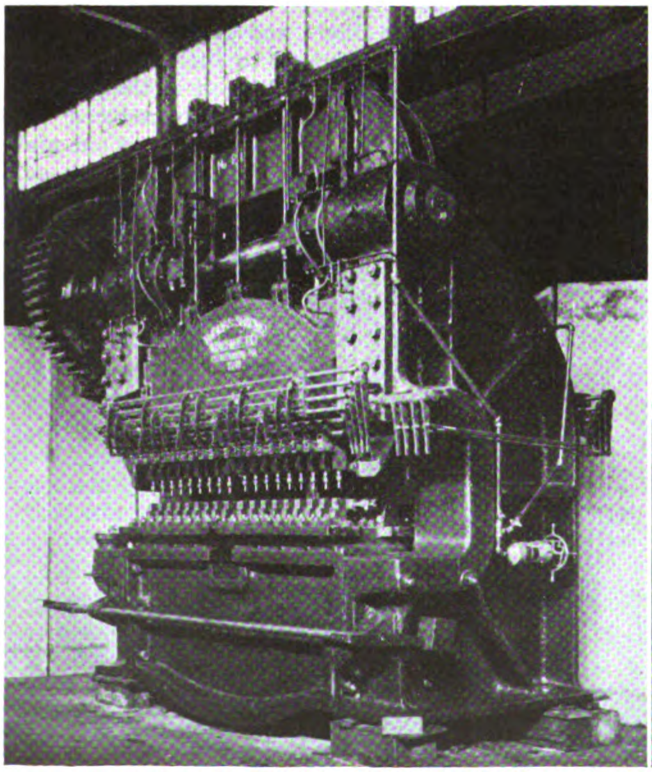
Silent chain drives are often lubricated by enclosing them in a case containing oil and having the chain dip into the oil at the lowest point. Where it is not feasible to use a case, chain drives are frequently lubricated by applying a heavy oil with a brush, to the back of the chain.

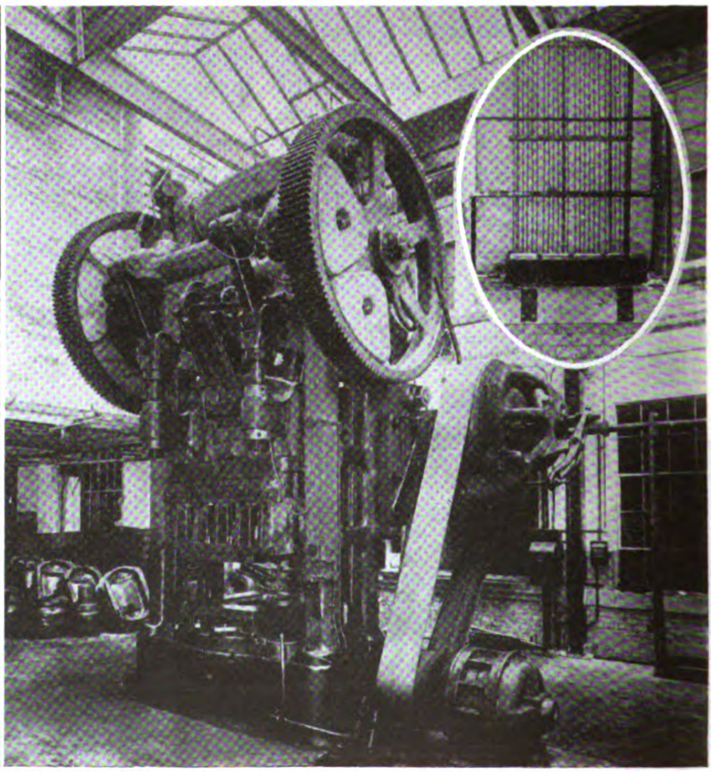
The third kind of lubricating device which was indicated, supplies the lubricant through a pressure feed device. One of the earliest types of pressure or positive-feed lubricating systems which was developed was what may be called the continuous system. This was originally adopted for engine and pump lubrication and generally was connected into the equipment so that a definite amount of lubricant was applied with each stroke or cycle of movement of the mechanism. Some of this equipment has been applied to machinery. However, but few machines need new oil each stroke or revolution and so as the equipment was originally designed, it was not well adapted to machine lubrication. Modifications, however, are widely used.

One of these types of devices which automatically feed oil to a number of bearings has been developed by the Madison-Kipp Corporation, Madison, Wis. This has been applied to machine tools and some special machinery. The lubricator consists of a pump which is operated by the machine through a worm gear. This lubricator may be regulated, it is stated by the manufacturer, to feed from 1 drop to 15 drops of oil per minute through anywhere from 4 to 100 outlets, and operates only when the machine operates. The oil is distributed to the various bearings from a central lubricator through small pipes which lead into the intricate and practically inaccessible (to a hand oiler) parts of the machine and thus assure continuous lubrication of the parts which would likely be neglected

Safety and reduced maintenance are two of the important reasons for using force-feed lubrication on large machines like these.

With force-feed lubrication the accident hazard and the possibility of human forgetfulness are largely eliminated. The punch press at the left is lubricated by a Keystone semi-automatic safety system (Keystone Lubricating Company, Philadelphia, Pa.) of grease lubrication. The safety lubricator is shown at the right end of the machine. Pressure is applied to the grease in the lubricator by turning the handwheel. This forces grease through the system of pipes to the various bearings. The operation of this lubricator is explained further in connection with the group of illustrations on page 217. The 500-ton Ferracute press at the right is lubricated from the McCord force-feed mechanical lubricator, (McCord Radiator & Manufacturing Company, Detroit, Mich.) which is mounted on the wall back of the machine, as shown in the oval. The oil is distributed to the various bearings through a system of pipes.



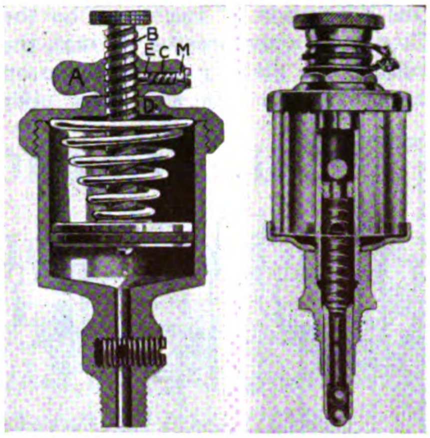


if the lubrication was wholly dependent upon the operator or an oiler.

Still another type of force-feed lubricator has been developed by the McCord Radiator and Manufacturing Co., Detroit, Mich. This also is a positive-feed device operated by the machine and the amount of oil delivered to each individual bearing or part may be adjusted, it is stated by the manufacturer. This adjustment takes care of the fact that some bearings require more oil than others. The oil is placed in a reservoir with a gage glass which indicates the amount of oil remaining. Practically all the attention required is to refill the reservoir as occasion demands. In the McCord lubricator the oil is also forced to the various parts of the machine through tubing which may connect up with practically any part of a complicated machine.

A modification of a system of lubrication, which was originally designed for engines, pumps and other reciprocating machines, is also applied by Wm. W. Nugent & Company, Chicago, Ill., to other lines of heavy machinery.

Still another type of positive-pressure lubricator is arranged to lubricate at the will of the operator. One device of this type which uses grease is manufactured by the Keystone Lubricating Company, Philadelphia, Pa. In the Keystone safety system of lubrication, grease is forced from a central grease station lubricator through pipes or tubes to the various bearings. This may be either intermittent or continuous according to the system used. With the intermittent system of lubrication the pressure is applied by the operator by screwing down the piston in the grease chamber or lubricator at intervals. This distributes the grease through the various tubes to the different bearings intermittently. A pressure reducing or regulating plug governs the quantity of lubricant applied to each bearing. This regulating plug may also be used to take care of the difference in distance between the lubricator and the various outlets which would affect the pressure on the grease at the different bearings.



Types of grease and oil lubricators which provide continuous feed.

The Chicago compression grease cup at the left (Ohio Injector Co., Wadsworth, Ohio) provides an adjustable spring compression on the grease in the cup. The amount of flow is regulated by turning the screw in the outlet. The Kelly lubricator at the right (Kelly Lubricator Co., Syracuse, N. Y.) gives a steady feed of oil to the bearings through the capillary action of the balls in the tip. One of these balls rests on the bearing and the other almost closes the stem leading to the oil cup. The rotation of the shaft rotates the ball which carries the oil down to the bearing.

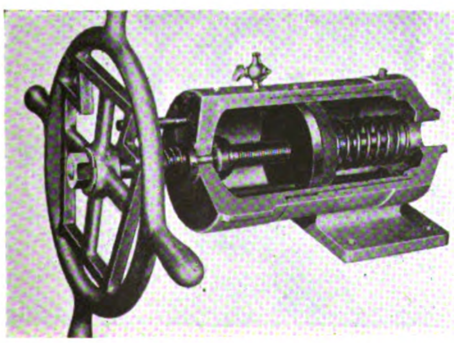
The Keystone system of lubrication may be made continuous by the addition of an automatic spring cup, such as is shown in an accompanying illustration. This spring grease cup is filled by screwing down on the hand lubricator which forces out the diaphragm of the spring cup. The springs then apply the pressure to the piston which gives a continuous pressure on the lubricating system and keeps the grease in the tubes under pressure. The grease is carried to the various bearings through light but strong tubing, or through a heavy grease-proof hose.

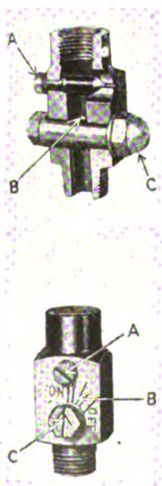
Still another type of intermittent lubricating device is incorporated in the Bowen system, manufactured by the Bowen Products Corporation, Auburn, N. Y. In this the tubes run from a pressure pump to the various bearings in much the same way as in the other positive lubricating systems. Oil is delivered to the various bearings by pushing down either by hand or by foot on a lever which operates the plunger of a pump which applies the pressure that is necessary to force the oil to each bearing. The Bowen system was developed for automobiles but is also applied to machine tools, and various other types of machines. The amount of lubricant delivered at each stroke of the piston may be regulated so as to govern the flow to the various bearings. Oil feeds down to the pump from a gravity tank; a strainer in the tank removes any sediment or foreign matter in the oil which might clog up the oil pipes in the system.

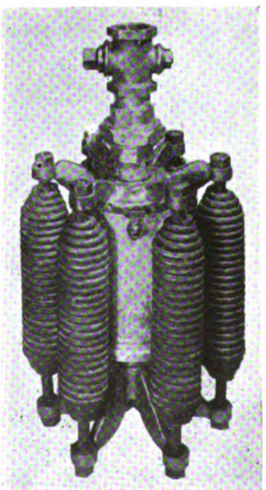
The big advantage of all of these positive-pressure methods of lubrication is that oil or grease is delivered to all bearings at the same time and so none are neglected or overlooked. In addition, in many types of machines it is unsafe for an operator or oiler to attempt to lubricate certain parts while the machine is in operation. This is particularly true of presses and other machines with large gears where a slip may cause a serious accident. Such bearings or oiling places are frequently neglected because of the danger involved when hand oiling is relied upon. With a positive oiling system such places receive their proper amount of lubricant. Some of the accompanying illustrations show various machines equipped with different types of positive oiling systems. It is com-

This is the mechanism which controls the Keystone safety grease lubricator.

The illustration at the left shows the compression chamber and the handwheel for applying the pressure to the grease. The cross-section and exterior views of the pressure-reducing valve (center illustration) indicate the method of regulating the amount of grease fed to the bearings. This valve is placed directly at the bearing and the amount of feed controlled by turning the screw *C*. The needle valve *A* is used to check the amount of pressure applied at the bearing. The automatic spring cup at the right is filled from the safety lubricator (left). The springs then apply pressure to the line to force the grease to the various bearings under continuous pressure. This is part of the Keystone equipment (Keystone Lubricating Company, Philadelphia, Pa.) for industrial grease lubrication.







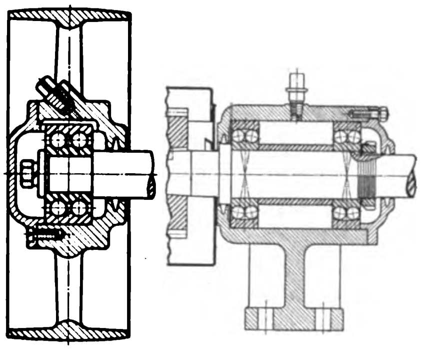
paratively easy for an operating man to visualize the difficulty incidental to the hand lubrication of some of the oil holes on these machines.

Comparatively recently as an outgrowth of the lubrication of automobiles the grease gun method of lubrication has been applied to industrial work. This equipment consists of a portable gun which applies the grease, or in some cases oil, under pressure, through a fitting in the oil hole of the bearing. As the lubricant is forced in under high pressure, it tends to work the old lubricant out to the side and carry with it foreign material or metallic particles which may be in the bearing. The fitting is kept closed by a ball on a spring in the opening. Fittings may be placed on the top, side or bottom of a bearing as may be most convenient for the oiler.

Two types of grease guns are manufactured by the Bassick Manufacturing Company, Chicago, Ill. One of these is known as the Alemite system and the other as the Zerk-Alemite system. The Alemite gun or compressor consists essentially of a cylinder, a piston which is screwed down to apply the pressure to the grease and a flexible or stiff tube or hose which is connected onto the nipple at the bearing.

Recently, however, the Zerk gun or compressor has been modified for industrial purposes and a special portable filling unit is used in connection with it, as shown in accompanying illustrations. The compressor consists of a cylinder to contain the grease, a pistol grip or handle connected to the main plunger and a nozzle with a small plunger to apply the high pressure to the grease. In operation, this gun is merely placed against the nipple on the bearing and the operator pushes down on the pistol-grip handle which acts through the plunger to force a definite quantity of grease into the bearing.

A special, portable filling unit is used in connection with the Zerk compressor for industrial work. This filling unit weighs 34 lb. when filled with 20 lb. of grease and can thus be carried around from department to department by the oiler. One revolution of the crank on the filler loads a compressor through the butt of the pistol grip as shown on page 215. In this way, the oiler always has plenty of grease with him and can fill the compressor, even in a dusty location, without exposing the grease to dust or other gritty substances that may be in the air.



Method of lubricating a ball-bearing loose pulley and a chain drive mounting.

The loose pulley at the left is fitted with SKF ball bearings. The provision for grease lubrication is indicated. The illustration at the right shows the mounting of the bearings for a chain drive connection to a textile mill. The chain drive is connected on the overhung sprocket at the left and the shaft extension at the right carries the pulley. These two sets of SKF ball bearings are spread apart and the chamber for grease lubrication is placed in between. Care must be exercised in the lubrication of ball or roller bearings to see that the grease or oil chamber is not filled too full of lubricant.

Where the Zerk-Alemite gun is used for filling cavity bearings, such as ball and roller bearings, or other grease reservoirs, where the lubricant is not necessarily applied under pressure but the gun is simply used as a filler, the special, high-pressure nozzle is removed and a straight tip placed on the gun. This is especially advantageous on ball and roller bearings where grease is not applied to the bearing under pressure. Furthermore, if the ball or roller bearing is completely filled, the bearing is likely to heat due to the churning of the lubricant. For this reason, it is usually unwise to fill a ball or roller bearing more than about one-third to one-half full of lubricant. With this low-pressure attachment, the gun is used merely as a filler and does not create pressure in the bearing.

Another type of high-pressure lubricator, known as the Dot lubricator, which is manufactured by the Carr Fastener Company, Cambridge, Mass., is used with either oil or grease. Pressure is applied by a turn of the handle, which also locks the tip of the gun on the special fitting at the bearing. The gun can be released from the fitting by turning it to the left.

A portable pressure gun, manufactured by the Adams Grease Gun Corporation, New York City, applies high-pressure grease lubrication through the operation of a lever handle. Special fittings are provided whereby the Adams gun may be used on the bearing fittings of the other standard systems of portable, high-pressure lubrication.

Any of these portable, pressure gun systems of lubrication may be applied to practically any type of machine or other bearing merely by putting a special fitting into the oil hole. In this way, any old machine or lineshaft can be quickly changed over to a more modern type of lubrication.

Still another type of pressure lubrication is obtained through the so-called circulating systems. In these, the oil is forced through the bearings under pressure, cooled, usually filtered or purified, and recirculated. Such systems are frequently used around large gears, such as in steel mills, on the helical or herringbone reduction gears on

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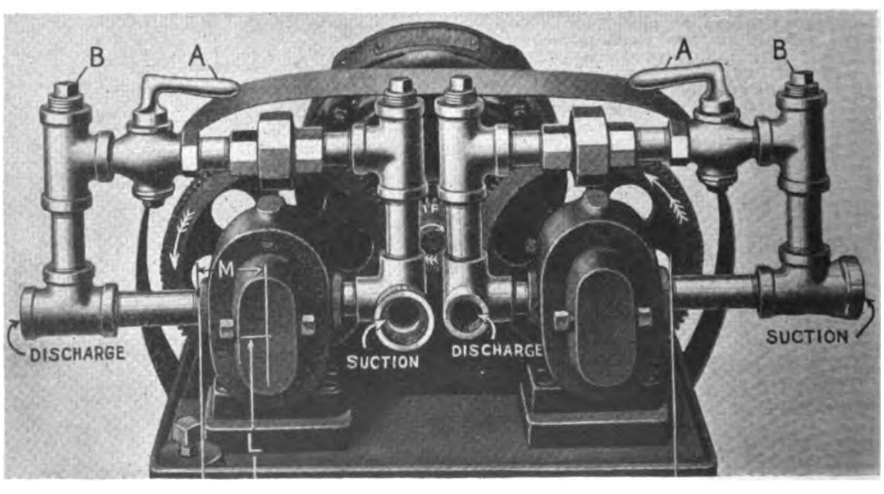


This motor-driven, duplex pump is used in a circulating lubrication system.

This pump is manufactured by Wm. W. Nugent & Company, Chicago, Ill., and is used to force the oil through the bearings of the machine and also through the oil filter. Filtering and cooling are important features of any circulating oiling system.

Things that you should know about

Control Equipment for Industrial Trucks

and small, battery-propelled, industrial locomotives, with graphs and diagrams that will aid in selecting the type best suited to the operating conditions

By R. B. HUNTER

Development Engineer, The Cutler-Hammer Mfg. Co., Milwaukee, Wis.

WITH the increased use of battery-propelled industrial trucks, the question of the proper types of controllers to be employed with them becomes of importance, and an outline of the principles involved in their selection and operation may be of interest.

Problems arising in the use of control equipment for battery operation are somewhat different from the problems encountered with the control for motors in ordinary power service. These differences arise from three causes: (1) The vehicle motor is usually designed for relatively low voltage, because of the high cost per volt of the storage battery. (2) The size and cost of the battery limits the energy available without recharging, and for this reason it is necessary to conserve the energy of the battery to the highest possible degree. (3) The service is extremely severe; vehicle controllers are subjected to more abuse than controllers in almost any other class of service.

For these reasons, vehicle controllers must be ruggedly constructed and usually are of relatively large size. The electrical parts must be made unusually heavy to reduce the voltage drop and the power loss, and the mechanical parts must be sufficiently strong to withstand the severe service. The controller must also provide special features that tend to reduce energy losses. The expense of these features is warranted by the battery limitations just noted, whereas this expense would not be justified in a controller for a motor deriving its energy from a power plant of conventional type.

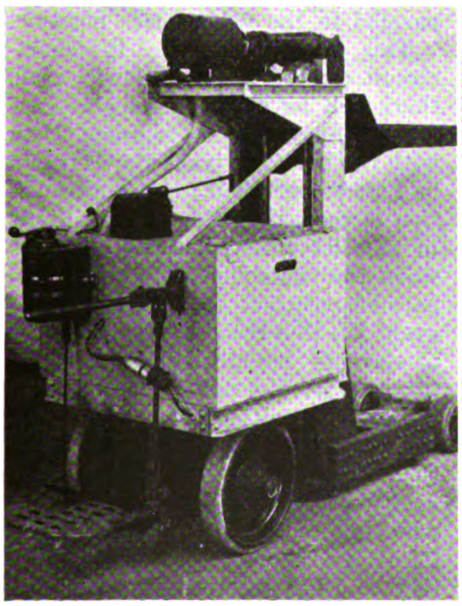
Energy losses in the electrical system of a battery-propelled vehicle are of two classes: (1) "Running losses," which comprise those losses that are due to the resistance of the motor, the leads, the controller contacts, the internal resistance of the battery and other parts of the electrical circuit. (2) "Accelerating losses," under which is classed the energy loss in the resistor which is introduced into the circuit to reduce starting torque to a desirable value.

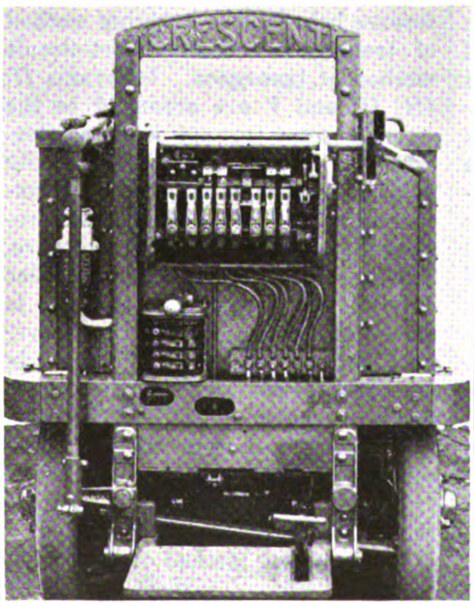
The running losses can be reduced only by liberal design of the parts; that is, the wiring must be heavy and a motor having a high efficiency should be used. Running losses in the controller can be reduced by minimizing the number of contacts through which the current must flow when the controller is in the high-speed position. A reduction of the number of contacts in the accelerating positions of the controller, while desirable to reduce maintenance, does not conserve battery energy, for the contact losses are negligible compared to the losses in the accelerating resistor. By "contacts" is meant not only the contact fingers and segments which make the necessary connections, but also contacts between wires, busbars, terminal lugs, and the like. All these parts must be of ample size and should be designed so that the contact surfaces can be set up tightly.

Since in all systems of vehicle control a resistor is introduced into the circuit during the accelerating period, it follows that the efficiency of the system is lower during ac-

Figs. 1, 2 and 3—The controller is the brains of the electric industrial truck.

Interlocking the controller with the brake is a necessity on an industrial truck. This prevents having power on the motor while braking and also prevents starting of the truck unless the operator is in position to pilot it. Fig. 1 (at left) shows a Tier-Lift truck manufactured by the Lakewood Engineering Co., which is equipped with a Cutler-Hammer controller. Fig. 2 shows the controller used on the type GEL Crescent elevating platform truck while Fig. 3 shows the drum controller used on an Elwell-Parker type EL Hi-Lo Tructor.





celeration than during running. Many methods have been devised to improve the efficiency and reduce the acceleration losses by reducing the ohmic value of the resistor. All of these high-efficiency schemes make use of series-parallel control during the acceleration period; that is, certain parts of the circuit are connected first in series and then in parallel or *vice versa*. The parts of the circuit which may thus be commutated are: (1) the motor field sections, (2) the battery; (3) the motors themselves in cases where there are two motors; or (4) some combination of the above. For example, the series field winding of the motor may be split into two sections, these sections being connected in series during acceleration and in parallel during running. This gives greatly increased torque per ampere during the acceleration period.

One of the problems inherent to all of these series-parallel systems is the transfer of the parts of the circuit from the series relation to the parallel relation or *vice versa*, with the minimum of controller complication, at the same time securing desirable operating characteristics.

There are three possible methods of effecting this transition. These are: (1) the open-circuit method; (2) the short-circuit method; and (3) the bridging method. The characteristics of these transition methods as applied to various elements of the circuit will be outlined.

A common method of securing improved accelerating efficiency is to divide the series field of the motor into two sections, connecting these sections in series to accelerate the vehicle, and then reconnecting them in parallel to propel the vehicle at full speed. This method is used on practically all industrial trucks and tractors. The graph shown at *A* in Fig. 4 gives the characteristics of a typical industrial truck motor; it will be noted that for a given current drawn from the battery, the torque with fields-series is considerably higher than the torque with fields-parallel. A high value of pound-feet per ampere is desirable during acceleration and the controller is, therefore, arranged to connect the field sections in series on the first two or three points. On the other hand, the efficiency of the motor is better and the speed higher with the fields connected in parallel and the controller provides this connection on the final point.

The transition from fields-series to fields-parallel is effected either by the short-circuit method or by the bridging method. A controller embodying short-circuit transition is shown in diagram *I* of Fig. 5. Diagrams *II*, *III*, *IV* and *V* of Fig. 5 show schematically the action that takes place when this controller is moved from the fields-series to the fields-parallel position. A controller providing bridging transition between fields-series and fields-parallel is shown in diagram *VI* of Fig. 5 and the steps of the transition are shown in the schematic diagrams *VII*, *VIII*, *IX* and *X* of Fig. 5.

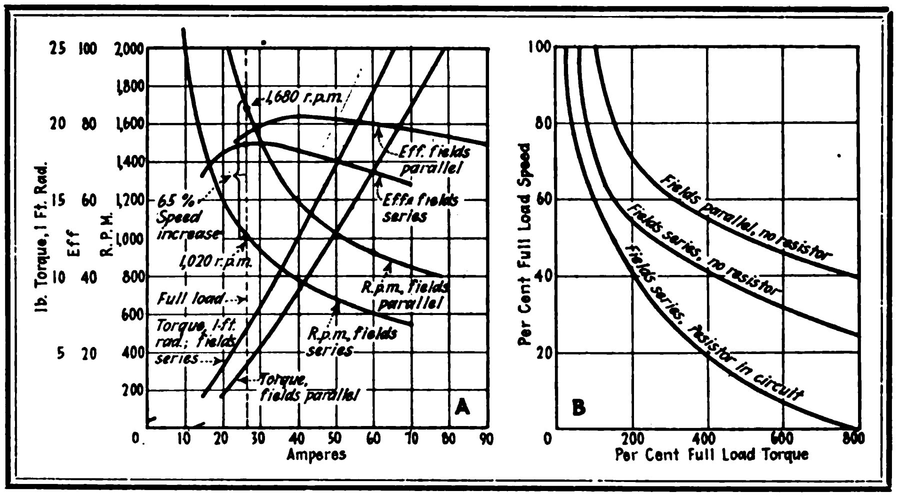


Fig. 4—Operating characteristics of industrial truck motors.

Diagram *A* shows the torque, speed, and efficiency curves for a truck motor when operating with its fields connected in series and also when its fields are connected in parallel. Note the increased torque obtained with the fields in series, and the increased speed obtained with the fields connected in parallel. Diagram *B* gives the speed-torque characteristics with fields-series and resistance, fields-series without resistance, and fields-parallel without resistance.

An examination of the schematic diagrams will show the essential difference between the bridging method of transition and the short-circuit method of transition. Diagrams *II*, *III*, *IV* and *V* are arranged in the sequence gone through when accelerating the motor. The motor with its fields connected in series is first connected across the battery with resistance in series with the armature. The second notch of the controller cuts out the series resistance, as is shown in diagram *II*. Further movement of the controller disconnects and shorts out one of the series fields, as shown in *III*. In diagram *IV* the short is removed from the series field that was disconnected from the armature circuit and in *V* the two series fields are paralleled.

The bridging method of transition is quite similar, except that the series field that is disconnected from the armature circuit is never open-circuited, but always has a bridging resistor shorted across it, as shown in diagrams *VIII*, *IX* and *X*.

When decelerating or shutting off the motor, the difference between the two methods of transition is quite marked. Diagrams *X* and *IX* show the first step in transition by the bridging method as the controller is moved from the fields-parallel position to the fields-series position. It will be noted that field *S1-S2* is disconnected at one end but is shunted by the bridging resistor, which provides a discharge path for the magnetic energy which was stored in this field. Referring now to diagrams *V* and *VI* of Fig. 5, it will be noted that field section *S1-S2* is similarly disconnected at one end; but since there is no bridging resistor to serve as a discharge path for the stored energy, this energy will be dissipated by an arc drawn from the controller finger which disconnects point *S2* from point *S12* as the controller is moved from the fields-parallel to the fields-series position.

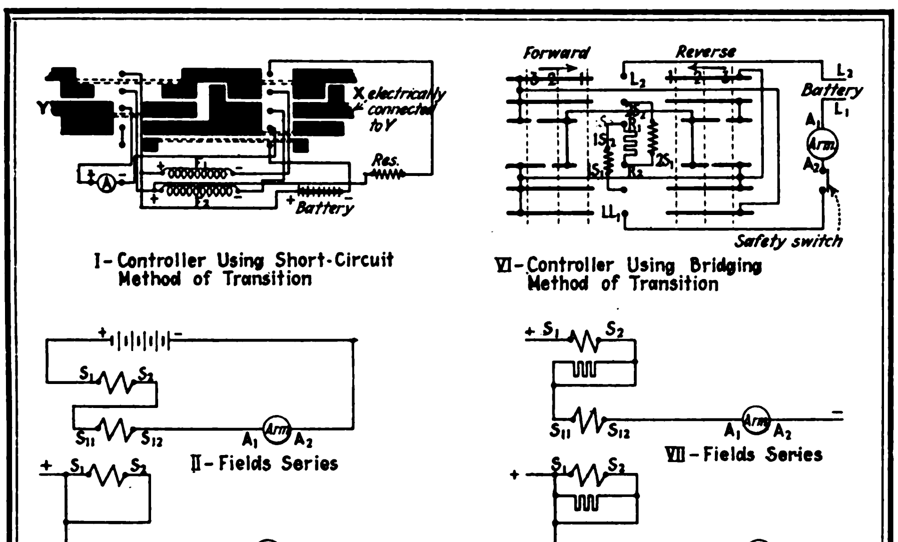
This means that when the short-circuit method of transition is used, there will be more burning of controller fingers and contacts than with the bridging transition. It will be noted that when bridging transition is used, the bridging resistor is in parallel with both field sections when the controller is in the fields-parallel position. As shown in diagram *VI*, this resistor serves also as a starting resistor to reduce the torque when the controller is thrown to the first position. In practice, this resistor is made of so high a value that when the controller is in the fields-parallel position, the current which flows in the resistor is negligible as regards drain on the battery, and has practically no effect on

the speed of the driving motor.

Diagram *B* of Fig. 4 shows the speeds that can be expected with various loads when a controller connected as shown in either diagrams *I* or *VI* of Fig. 5 is used. The series resistor is so proportioned that when the controller is thrown to the first notch the motor will exert a torque equal to approximately eight times the full-load torque of the motor. This is comparable to the low gear of an automobile where the normal engine torque is greatly increased by the use of a gear reduction. The torque on the first controller point is sufficient to start a very heavy load, and at the same time the speed obtained on this point when the vehicle is fully loaded is only about half of the normal speed of the vehicle. When the controller is thrown to the second notch a still higher torque will be exerted if required, and the speed with full load on the vehicle will be about 75 per cent of normal speed. When the controller is thrown to the third point the maximum speed is obtained.

Probably the oldest method of improving the accelerating efficiency of a battery-propelled vehicle is to divide the battery into two or more parts, connecting these battery sections in parallel to afford low voltage when starting from rest, and then reconnecting them in series as the motor gains speed. This method is used only on battery-propelled vehicles using a battery potential of 80 volts or higher and consequently is practically never used on the usual size of industrial truck or tractor. It is, however, used on some types of industrial locomotives and on commercial trucks. While the battery has sometimes been divided into three or more sections, it is the more usual practice to divide it into halves, thus affording two accelerating voltages. The transition from battery-sections parallel to battery-sections series can be effected either by the open-circuit method or by the bridging method. A controller providing open-circuit transition is shown in diagram *I* of Fig. 9 and a controller providing bridging transition is shown in diagram *II* of Fig. 9. As indicated by the term, when open-circuit transition is used, the circuit is completely opened in passing from batteries-parallel to batteries-series. When bridging transition is used the battery is connected first in parallel and is finally connected in series, with three intermediate points between the parallel connection and the series connection.

Fig. 5—These diagrams show the difference between the short-circuit method and the bridging method of transition from fields-series to fields-parallel.



When open-circuit transition is used the torque is momentarily interrupted in passing from batteries-parallel to batteries-series, whereas when the bridging method is used the torque is continuous throughout the entire movement of the controller handle. This maintenance of torque is, however, secured at the expense of controller complications and additional resistors in which there is necessarily some energy loss. The interruption of torque during the open-circuit transition is of very short duration and this method of control is usually preferred to bridging transition for shifting from batteries-parallel to batteries-series or *vice versa*.

When the vehicle is driven by two motors, such as is often the case in industrial locomotives, the motors are connected in series during the acceleration period and in parallel during the starting period. When the motors are connected in series the voltage across each motor is only one-half of the battery voltage, and the resistor required to reduce the starting torque to a desirable value is considerably less than would be required if the motors were connected in parallel during the acceleration period; in fact, the resistor losses are reduced by one-half by using the series-parallel scheme.

The transition between motors-series and motors-parallel can be effected by any one of the transition schemes above enumerated. In practice, however, open-circuit transition is rarely used.

Diagrams showing typical controllers embodying the short-circuit method of transition and the bridging method of transition are shown respectively in diagrams *I* and *VII* of Fig. 10. Diagrams *II, III, IV* and *V* show schematically the steps in transition between motors-series and motors-parallel when the short-circuit method of transition is used. Diagram *II* shows the motors connected in series. It will be noted that there are several steps of resistance, these steps being successively short-circuited so that on the third or fourth controller point the motors connected in series have full line voltage impressed upon them. In diagram *III*, which is the first step of transition to motors-parallel.

it will be noted that motor No. 2 is short-circuited and that full line voltage is impressed on motor No. 1 in series with its resistor. The next step is to disconnect motor No. 2 from the line as shown at *B*, in *IV*. The final step of the transition to motors-parallel, as shown in *V*, is to connect motor No. 2 to the line, thus putting each motor across full voltage in series with its separate resistor. (Sometimes the connections are such that when the motors are in parallel a common resistor is used for the two motors.)

By comparing diagrams, *II*, *III*, *IV* and *V* of Fig. 10 with the corresponding diagrams in Fig. 5, it will be noted that short-circuited transition for two-motor control is analogous to the short-circuit method of transition between fields-series and fields-parallel. That is, the steps in the transition are identical, substituting motors for field sections.

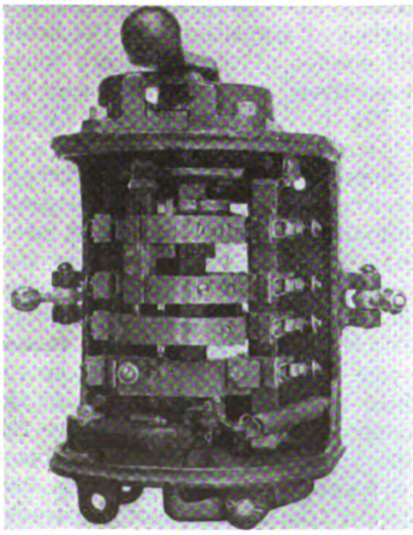
However, injurious arcing is not experienced in passing from the connections shown in *V* to *IV* of Fig. 10, whereas, as noted before, in connection with series-parallel transition of field circuits, arcing is encountered under this condition. The reason for the reduction in the arcing when commutating motors as against commutating fields in this manner, is that the motor counter-voltage tends to reduce the arcing, whereas when the fields are commutated there is no such counter-voltage, and the heavy inductance of the field tends to prolong the arc and thus burn the controller contacts.

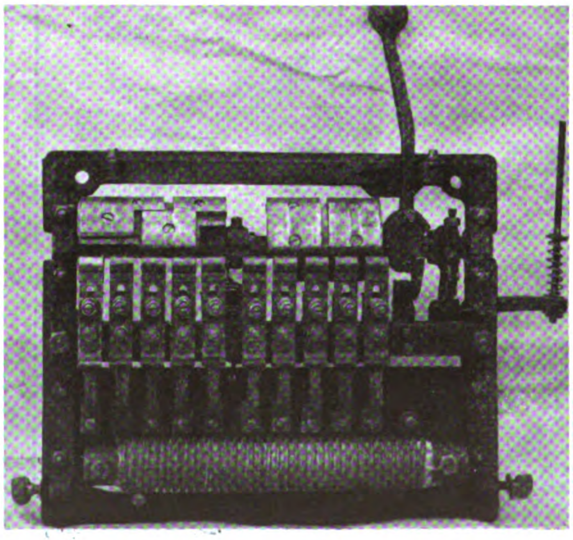
Diagrams *VIII*, *IX*, *X* and *XI* of Fig. 10 show the steps of transition between motors-series and motors-parallel when the bridging method of transition is used. As shown in diagram *VIII*, the motors are first connected in series with resistance in the circuit, which resistor is short-circuited in three or four steps as shown by the dotted lines. The connections shown in diagram *IX* are next established. It will be noted that jumper *A* is introduced to connect the motors in series, and that the resistor circuit is opened at *B*. Connection is then made between each side of the line and each resistor, as *C* in diagram *X*. If the resistors are of proper value and the motors are equally loaded (as is usually the case), no current will now flow in jumper *A*. Diagram *XI* shows the motors connected in parallel, with jumper *A* opened.

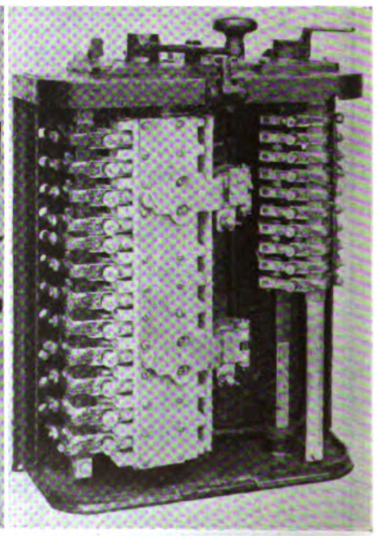
It will be noted that in this method of transition, torque is maintained on both motors throughout the transition period. The curves in *VI* of Fig. 10 show the relation between speed and torque when the connection schemes shown in *I* or *VII* of Fig. 10 are used.

Controllers for industrial trucks are practically always of the drum type. A typical controller is shown in Fig. 6. This type of controller consists of a metal spider upon which are mounted copper segments of the proper length and spacing to make contact in proper sequence with fingers to which the external connections to the motors, battery and resistor are made. The drum type of controller is used because it is rugged and durable, is easily operated and lends itself readily to the commutation of the circuits as described above. Although the currents which must be handled by these controllers are large, due to the low voltage of the battery, the horsepower rating is low, not being greater than 10 hp. as a maximum. For this reason a manually-operated, drum-type controller is entirely satisfactory and magnetically-operated controllers are rarely, if ever, used. Magnetically-operated vehicle controllers are somewhat unsatisfactory because of the rough roads which are sometimes encountered and because of the wide variations in battery voltage which make it difficult to secure satisfactory operation of the contactor coil.

The drum-type controllers used on vehicles may be divided into two general types, namely: (1) The single-cylinder type, as used on industrial trucks; (2) the two-cylinder type, as used on industrial locomotives. In the single-cylinder type, all of the copper segments are mounted on one cylinder, and all of the operations of the vehicle are under the control of one handle. Single-cylinder drum controllers for an industrial truck for indoor factory service are shown in Figs. 6 and 7. These controllers are shown in Figs. 1, 2 and 3, mounted on







Figs. 6, 7 and 8—Here are the working mechanisms of three controllers for battery-propelled vehicles.

Fig 6 (left) shows a Cutler-Hammer drum controller for industrial truck service. Fig. 7 (center) shows controller used on the Mercury tractor. The five fingers on the right are the reversing fingers and the segments are moved longitudinally along the shaft to engage the four right-hand fingers for one direction and the 2nd, 3rd, 4th and 5th fingers from the right for the other direction. The rod at the extreme right engages with the seat on the tractor. When the operator sits on the seat, the controller is held in the running position as long as the handle is held in a speed position. When the operator gets off the seat, a pawl is disengaged freeing the drum from the handle, whereupon a spring pulls the main drum to the off position. Fig. 8 (right) is a two-cylinder controller such as used on industrial locomotives. The right-hand drum controls the direction of travel, while the left-hand drum controls the acceleration and speed.

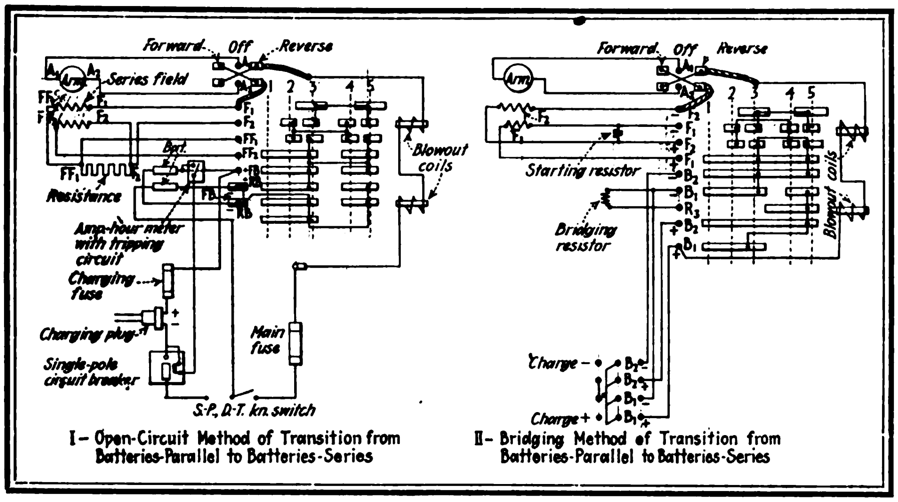


Fig. 9—Connection diagrams for open-circuit and bridging methods of transition from batteries-series to batteries-parallel.

trucks as they are generally used.

It will be noted that in Fig. 1, a rod connects the foot pedal of the truck with the controller. The operator rides on the platform of the truck, holding the foot pedal depressed to release the brake. The rod between the foot pedal and the controller operates a safety switch which is so arranged that as the pedal is released to apply the brake, the safety switch is opened. This safety switch is the arm connecting the bottom contacts on each side of the controller shown in Fig. 6. It serves two purposes: (1) It insures that power is not applied to the truck motor when the brake is applied. (2) By means of an interlock between the main cylinder and the safety switch, it insures that the controller must be in the "off" position before the *safety switch* can be closed, so that in case the operator leaves the truck with the controller set in a running position, it will not start if he carelessly steps on the brake pedal without first returning the controller to the neutral position.

The safety switch is purposely so made that it is closed when the controller is returned to the neutral position, and is then held closed by a latch operated by the brake pedal. When the brake pedal is released with the controller in a running position, a spring snaps the safety switch to the open position. This quick-break feature reduces the burning on the safety switch contacts, which otherwise would deteriorate rapidly because in normal operation the truck is usually stopped by releasing the safety switch and applying the brake, rather than by moving the controller to the "off" position.

The fingers shown in Fig. 6 have proven very satisfactory in controllers for battery-propelled vehicles. The proportions of this design are such that heavy contact pressure is secured and at the same time the finger does not stub on the end of the segment but rides up on it, without undue pressure on the operating handle. The finger is adjustable for wear by means of a micrometer screw and a heavy copper pigtail reduces the loss between connection and finger tips.

In the two-cylinder type, the acceleration of the motor is usually under the control of a large cylinder known as the main cylinder, and reversal is effected by a cylinder of smaller capacity operated by a separate handle. The reverse cylinder is interlocked with the main cylinder so that the reverse cylinder can be operated only when the main cylinder is in the open circuit position. All of the arcing is thus confined to the main cylinder, whose contacts are made relatively heavy and are sometimes provided with blowouts to reduce the flashing. A controller of two-cylinder type is shown in Fig. 8.

This type of controller is largely used on mine and industrial locomotives. Two-cylinder controllers are also used on road trucks, the reverse cylinder being operated by a foot pedal. In this case the reverse cylinder is held normally in the forward position by a spring, and is depressed by the operator's foot only when he wants to go backwards.

There are three factors to consider in choosing a resistor for a battery-propelled vehicle: namely, (1) the mechanical structure; (2) the ohmic value; and (3) the current-time capacity.

The mechanical structure generally used is the cast-iron grid mounted on rods and supported on pressed-steel end plates. A special grid of short rib length and small cross-section is sometimes used for industrial trucks. The low voltage and relatively low motor rating used on these trucks require a grid of comparatively low resistance and small capacity, whereas the design must be such as to offer resistance to vibration and shock. For large trucks and industrial and mine locomotives the standard grid used for general controller work is entirely satisfactory. Punched steel and alloy grids of greater strength than cast iron are sometimes used, but when mounted with reasonable care the cast-iron grid gives no trouble. Resistors made from alloy wire are also used, as is shown in Fig. 7.

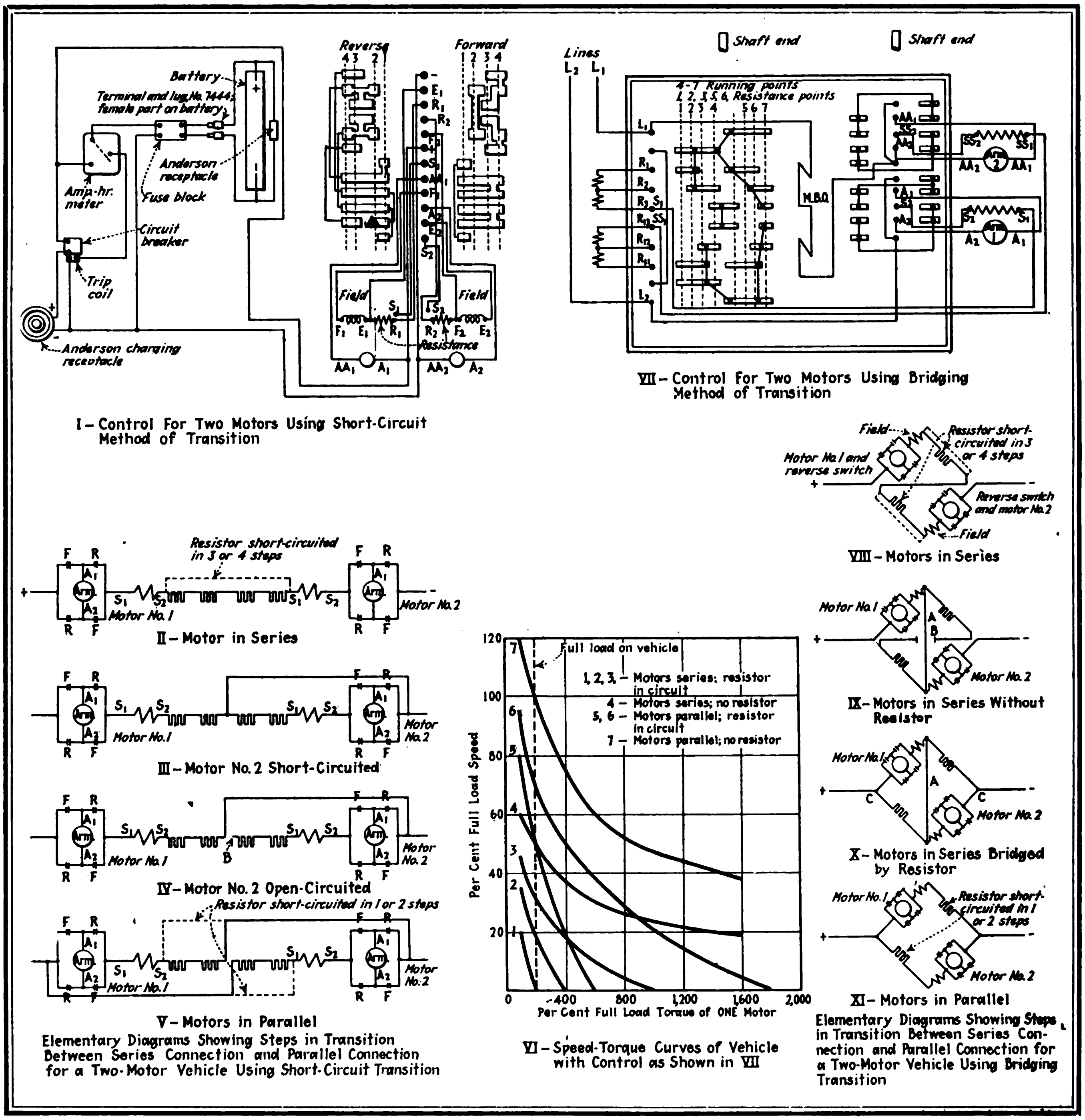
The ohmic value of the resistor will vary with the type of vehicle and the service to be encountered. The results to be obtained are: (1) Sufficient torque must be provided to start the load on the first controller point. (2) The truck must start smoothly. (3) The driving wheels of the truck must not slip with the controller on the first point. When tired wheels are used, as on industrial locomotives, some difficulty may be experienced in meeting conditions (1) and (3), especially since the trailing load on the locomotive may vary from nothing to a considerable overload. If, with the controller on the first point, the torque is enough to start a heavy load, the wheels will be likely to slip if the locomotive is pulling a small load. For this reason, an extra number of points is provided on mine locomotive controllers, the torque on the first point being sufficient to start only a light load. If the load is heavy, the control handle must be moved to the second or third point to start.

Industrial trucks and road vehicles do not present this problem for the following reasons: (1) Because the variation in load between loaded and empty vehicle is not so great. (2) Because with rubber tires there is little tendency to slip the wheels. While practice varies considerably, the conservative value of current to be allowed on the first controller point for an industrial locomotive is 100 per cent of the 1-hr. current rating of the motor (or of both motors, if two motors are used) and for an industrial truck it is 150 per cent of the 1-hr., current rating.

The current-time capacity of the resistor likewise depends on the

service required of the vehicle. For example, a switching locomotive will require greater resistor capacity than is required on a locomotive used on long hauls. For general service, however, resistors that meet the requirements of Electric Power Club classification No. 54 will be found satisfactory, based on the 1-hr. rating of the vehicle motor, if series acceleration is used. If series-parallel battery or motor acceleration is used, the total amount of resistor material will be only one-half of that required for series acceleration.

The remaining control accessories are the charging plug and receptacle, the ampere-hour meter, and the fuses or circuit breakers. Typical charging plugs and receptacles are shown in Figs. 1, 2 and 3. Removing the plug from the receptacle completely disconnects the battery from the motor and control circuit. Another plug from the charging apparatus is inserted in the receptacle during charging. It is becoming more and more the practice to equip all battery-propelled vehicles, and particularly industrial trucks and tractors, with ampere-hour meters. These indicate to the truck operator not only the amount of charge remaining in the battery but also tell when the battery is completely charged and will automatically disconnect the battery from the charging circuit. Circuit breakers are not usually used on industrial trucks, although they are in some cases used on industrial locomotives. The more common practice is to use fuses for protection to the motor and wiring.



I – Control For Two Motors Using Short-Circuit Method of Transition

VII – Control For Two Motors Using Bridging Method of Transition

II – Motor in Series

III – Motor No. 2 Short-Circuited

IV – Motor No. 2 Open-Circuited

V – Motors in Parallel

Elementary Diagrams Showing Steps in Transition Between Series Connection and Parallel Connection for a Two-Motor Vehicle Using Short-Circuit Transition

VI – Speed-Torque Curves of Vehicle with Control as Shown in VII

VIII – Motors in Series

IX – Motors in Series Without Resistor

X – Motors in Series Bridged by Resistor

XI – Motors in Parallel

Elementary Diagrams Showing Steps in Transition Between Series Connection and Parallel Connection for a Two-Motor Vehicle Using Bridging Transition

Fig. 10—Control schemes for two-motor drive on industrial locomotives.
Diagram *I* shows a controller using the open-circuit method of transition and diagrams *II, III, IV,* and *V* give the steps in the transition. Diagram *VII* gives the scheme for a controller using the bridging method of transition, while diagrams *VIII* to *XI* inclusive give the steps in the transition. Diagram *VI* gives the speed-torque characteristics when using either method of control.

How to work out

Changes in Windings of Single-Phase Motors

together with details of methods used in laying out starting and running windings when the original winding data are not available

By A. C. ROE
Renewal Parts Engineering Dept. Homewood (Pa.) Works, Westinghouse Electric & Mfg. Co.
and
D. H. BRAYMER
Consulting Editor, Industrial Engineer

IT IS USUALLY easy enough to rewind a single-phase motor exactly as it was wound at the factory, when all the data on the original winding are available. It is not so easy, however, to make changes in the distribution of the running and starting windings of a single-phase motor and be sure of the results, without considerable experience in this work or a full understanding of the design principles involved. In this article practical details are given on the changes that it is possible to make in such windings. In addition, complete data are shown for the windings used on a number of single-phase motors, which will be found useful when laying out a new winding or changing an old one.

SINCE the appearance of our book, "Rewinding Small Motors," published by the McGraw-Hill Book Company, letters have been received from several readers asking for information that borders on the design of small single-phase motors, rather than on the rewinding of standard designs. While it is not always advisable to change the design of small motors without first securing full data on the original winding from the motor manufacturer, there are certain fundamentals of design that can be effectively employed to determine the limitations of possible changes. An understanding of these fundamentals will help to prevent mistakes and aid in laying out a new winding when cores have been stripped before being received, or in correcting the mistakes of others who have changed the original winding so that satisfactory operation has not been secured, calling for other changes or a complete new rewinding job. The following information will be of interest in such cases.

The conditions that will be discussed are as follows: (1) Method of laying out new running and starting windings for a small single-phase motor when it is desired to rewind an old core and the original winding data are not known. (2) Method of laying out a new starting winding for a small motor in which the main or running winding is intact, but the starting winding data have been lost or a mistake was made in a previous rewinding job, resulting in such unsatisfactory operation that rewinding is made necessary.

The first point to consider in any case when a single-phase winding is changed is the horsepower the motor frame is good for, which assumes that this information is not available from the nameplate or that the nameplate has been removed. To assist in determining the rating of the frame and securing the other data, Table I has been worked up for ready reference.

In Table II data are given for 14 typical single-phase motor windings. From this information the turns per slot and per pole and the size of wire for ratings from 1/30 hp. up to 1 hp. can be secured, together with much other data that will be found helpful in many instances.

When using this tabulated information, the first thing to do is to find the rating possible for the core under consideration. To do this, measure the bore and length of the core and then refer to the data for the typical windings given and match up your data with those given in one of the examples, so as to insure a conservative rating for the core that must be rewound.

The next step is to find the total number of turns per pole. Here again the tabulated information for the 14 typical motor windings will help to simplify calculations and save considerable time, as well as avoid possible mistakes in long calculations. The examples provided give good standard methods for distributing the turns over the pole face area, that have been found to be good practice and result in good motor operation. Therefore, instead of tabulating the flux per tooth in relation to a sin curve and the ampere turns and factor for determining the conductors per slot, we can find the total flux per pole (phase) and then the turns per pole from the tabulated information presented.

To determine the total flux per pole, it will be necessary to assume values for the air gap density in lines of force per square inch. The following values will be found satisfactory:

Up to 1/8 hp. 20,000 lines per sq. in.
For 1/4 hp. 25,000 lines per sq. in.
For 1/2 hp. 30,000 lines per sq. in.
For 1 hp. 35,000 lines per sq. in.

Then find the area of each pole in square inches and multiply this by one of the above values of lines per square inch for the required horsepower of the frame. The area of the pole in square inches equals (the stator bore in inches times 3.1416 times the length of the core in inches) divided by the number of poles. This may be expressed in the shape of a formula as follows:

$$A=(B\times N\times L)\div P,$$

where A is the area in square inches, B the bore of the stator, N a factor,

Table I—Minimum Cylindrical Inches for Maximum Single-Phase Rating of Four-Pole, 1,800-R.p.m., 60-Cycle Motors

B×B×L	Single-Phase Hp.	Remarks
18.0	1/4	B equals bore of stator, and L equals length of core in inches.
30.0	3/8	$B\times B\times L$ required for six-pole motors equals 1.5 times ($B\times B\times L$ for four poles).
37.5	1/2	
60.0	3/4	$B\times B\times L$ required for eight-pole motors equals 1.85 times ($B\times B\times L$ for four poles).
45.0	1.0	

3.1416, L the length of the core and P the number of poles.

The total number of lines of force (flux) per pole phase equals the lines per square inch times the total square inches per pole.

The turns per pole (T) equals (370,000 times E) divided by the total flux per pole. This is for 60-cycle motors only, for which data are also given in the tabulated data. E in this formula is the single-phase voltage.

From the above calculations the total number of turns per pole is obtained and the next step is to arrange these turns into the proper number of turns per slot or per skein. To simplify this, it can be assumed in all cases that both the starting and the running windings will be skein wound. Then turn to the typical examples of motor windings, in Table II, where the number of times that the skein is passed through each slot is given. In these examples the figure *1* indicates that the skein is passed through the slot only once, and the figure *2* that the skein is passed through a slot twice, and so on.

For example, refer to winding No. 12. In the main winding the skein passes through slot *7* once, through slots *8*, *9*, *10*, *11* and *12*, twice, and through slot *13* once, or a total of 12 times per pole. In this case the total turns per pole equals the turns per skein times the skein factor (*SF*) per pole. That is, $32\times12=384$ turns per pole.

On the other hand, if we know the total turns per pole and want to find the turns per skein, simply divide the turns per pole by the skein factor, *SF*, given for the windings considered in examples Nos. 1 to 14. Take for example winding No. 4. The running winding has 368 turns per pole and the skein factor, *SF*, is 8. Then the turns per skein equal $368\div8=46$ turns. To convert turns per skein into turns per slot, multiply the turns per skein by the figure in each running winding slot. Refer again to winding No. 4. Here slot *5* would have 1 times 46, or 46 turns. Slot *6* would have 2 times 46 or 92 turns, and in slot *7*, where two coils overlap, the turns per slot for each coil would, of course, be 1 times 46, or 46 turns.

The next step after determining the proper number of turns, is to find the size of wire to use for the running and the main windings. In general the wire should be as large as can be wound into the slots. In estimating the sizes required the following sizes can be used, taken from the current values given in the typical windings, in Table II, below.

Up to ⅛ hp. use 250 to 375 circ. mils per ampere.
For ¼ hp. use 400 circ. mils per amp.
For ½ hp. use 425 circ. mils per amp.
For 1 hp. use 450 circ. mils per ampere.

Table II—Winding Data for Fourteen Typical Single-Phase Motors Designed for 60-Cycle Circuits

Winding No. 1—For 1/30-hp., 110-volt, 1.25-amp., 60-cycle, 1,700-r.p.m., four-pole motor, 24 slots, 2¾-in. bore, 1¼ in. long.

Slot No.	1	2	3	4	5	6	7	8	9	10	11	12	13
Main winding	1/1	2	1		1	2	1/1	2	1		1	2	1/1
Start winding				2/2	4				4	2/2			

Main winding—50 turns of one No. 25 (.0179 in.) d.s.c wire. Skein factor *SF* equals 8.
Start winding—14 turns of one No. 30 (.0100 in.) d.s.c. wire. *SF* equals 12.
Turns per pole—168 for starting and 400 for main or running winding. Starting turns 42 per cent of running turns.
Running and starting windings skein-wound. Series connection used.

Winding No. 2—For 1/12-hp., 110-volt, 60-cycle, 1,725-r.p.m., four-pole motor, 24 slots, 2¾-bore, 1⅜ long.

Slot No.	1	2	3	4	5	6	7	8	9	10	11	12	13
Main winding	1/1	2	1		1	2	1/1	2	1		1	2	1/1
Start winding				1/1	2				2	1/1			

Main winding—40 turns of one No. 23 (.0226 in.) d.s.c. wire. *SF* equals 8.
Start winding—25 turns of one No. 27 (.0142 in.) d.s.c. wire. *SF* equals 6.
Turns per pole—320 main and 150 starting. Starting turns 47 per cent of running turns. Both windings skein-wound. Series connection.

Winding No. 3—For 1/6-hp., 110-volt, 3,400-r.p.m., 60-cycle, two-pole motor, 3.6-amp., 24 slots, 3-in. bore, 1½ in. long.

Slot No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Main winding	1	1	1	1	1			1	1	1	1	1						
Start winding							1	1	1	1	1			1	1	1	1	1

Main winding—36 turns of one No. 16 (.0508 in.) d.c.c. wire. *SF* equals 10.
Start winding—30 turns of one No. 27 (.0142 in.) d.s.c. wire. *SF* equals 10.
Turns per pole—360 main and 300 starting winding. Starting turns 83 per cent of running turns. Both windings split skein-wound. Series connection.

Winding No. 4—For 1/6-hp., 110/220-volt, 1,725-r.p.m., 60-cycle, four-pole motor, 24 slots, 3⅛-in. bore, 1⅝ in. long.

Slot No.	1	2	3	4	5	6	7	8	9	10	11	12	13
Main winding	1/1	2	1		1	2	1/1	2	1		1	2	1/1
Start winding				1/1	2				2	1/1			

Main winding—46 turns of one No. 22 (.0254 in.) d.c.c. wire. *SF* equals 8.
Start winding—34 turns of one No. 28 (.0126 in.) d.s.c. wire. *SF* equals 6.
Turns per pole—368 main and 204 starting winding. Starting turns 56 per cent of running turns.
Both windings skein-wound. Series connection for 220 volts and two-parallel for 110 volts.

Winding No. 5—For 1/6-hp., 220-volt, 1.9-amp., 1,725-r.p.m., 60-cycle, four-pole motor, 36 slots, 3¾-in. bore, 1½ in. long.

Slot No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Main winding	1/1	2	2	1			1	2	2	1/1	2	2	1			1	2	2	1/1
Start winding						1	1						1	1					

Main winding—36 turns of one No. 22 (.0254 in.) d.s.c. wire. *SF* equals 12.
Start winding—61 turns of one No. 26 (0.159 in.) d.s.c. wire. *SF* equals 4.
Turns per pole—432 main and 244 starting. Starting turns 56 per cent of running turns.
Both windings skein-wound. Series connection.

Winding No. 6—For 1/6-hp., 220-volt, 60-cycle, 2.2-amp., 1,725-r.p.m., four-pole motor, 36 slots, 3½-in. bore, 1⅝ in. long.

Slot No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Main winding	2	2	1			1	2	2		2	2	1			1	2	2	
Start winding				2	2				4				2	2				4

Main winding—37 turns of one No. 20 (.032 in.) d.s.c. wire. *SF* equals 10.
Start winding—32 turns of one No. 28 (.0126 in.) d.s.c. wire. *SF* equals 8.
Turns per pole—370 main and 256 starting. Starting turns 69 per cent of running turns.
Both windings skein-wound. Series connection.

After finding the size of wire from the above data, and after the turns per slot and size of wire for the starting winding have been determined, it is a good plan to try the total number of wires in one slot, that is, the total number of running and starting wires, and if possible increase the running winding wire one size. In case the starting winding wires make the slot full and tight, the starting winding wire size can be reduced one size without bad effects so as to give a liberal size for the running winding. This completes the necessary data for figuring out the running winding.

The starting windings of split-phase motors are designed to give phase displacement. This is accomplished by making the resistance of the starting winding high as compared to the resistance of the running winding. The resistance of the starting winding is proportioned so as to limit the starting current to 4 to 6 times the current that is taken at full load.

However, to work out the starting winding by the resistance method calls for calculations that are likely to cause mistakes. It is safer to use known values taken from good existing windings, such as in the windings given in Table II, and then calculate the starting winding data by percentages based on the turns per pole of the running winding, as there is less likelihood of making annoying mistakes.

In the tabulated windings Nos. 1 to 14 the percentage of starting winding turns per pole to the running winding turns per pole has been given in each case. On an average, the turns per pole for the starting winding can be considered as 62 per cent of the running winding turns per pole. Or if any winding that is being worked out checks up with any one of the typical windings, the starting winding data can be taken directly from the tabulated winding data with good results. From 50 to 65 per cent of the running winding turns can be safely used for the turns per pole for the starting winding and a satisfactory winding will result.

The next step in laying out the starting winding is to determine the size of wire. This can also be done by using the running winding as a base. From the windings given in Table II it will be found that for four-pole motors the size of wire for the starting winding runs from four to eight sizes smaller than the running winding, or that on an average the starting winding wire size can be made six or seven sizes smaller than the running winding wire size. Then for a two-pole motor winding, the starting wire will be 11 sizes smaller than the wire used in the running winding. For

Table II—Winding Data for Fourteen Typical Single-Phase Motors Designed for 60-Cycle Circuits

(Continued from the preceding page)

Winding No. 7—For ⅛-hp., 110/220-volt., 2.5/1.25-amp., 60-cycle, 1,725-r.p.m., four-pole motor, 24 slots 3⅛-in. bore, 1¼ in. long.

Slot No.	1	2	3	4	5	6	7	8	9	10	11	12	13
Main winding	1/1	2	1		1	2	1/1	2	1		1	2	1/1
Start winding				1/1	2				2	1/1			

Main winding—70 turns of one No. 23 (.0226 in.) d.c.c. wire. *SF* equals 8.
Start winding—58 turns of one No. 30 (.0100 in.) d.s.c. wire. *SF* equals 6.
Turns per pole—560 main and 464 starting. Starting turns 82 per cent of running turns.
Both windings split-skein. Series connection for 220 volts and two-parallel for 110 volts.

Winding No. 8—For ⅛-hp., 220-volt, 60-cycle, 1,750-r.p.m., four-pole motor, 24 slots, 3-in. bore, 2 in. long.

Slot No.	1	2	3	4	5	6	7	8	9	10	11	12	13
Main winding	1/1	2	2		2	2	1/1	2	2		2	2	1/1
Start winding				2/2	1	1		1	1	2/2			

Main winding—44 turns of one No. 22 (.0254 in.) d.s.c. wire. *SF* equals 10.
Start winding—38 turns of one No. 29 (.0113 in.) d.s.c. wire. *SF* equals 8.
Turns per pole—440 main and 304 starting. Starting turns 70 per cent of running turns.
Both windings skein-wound. Series connection.

Winding No. 9—For ¼-hp., 110-volt, 60-cycle, 3,400-r.p.m., two-pole motor, 24 slots, 3¼-in. bore, 1⅞ in. long.

Slot No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Main winding	1	1	1	1	1			1	1	1	1	1						
Start winding							1	1	1	1	1			1	1	1	1	1

Main winding—64 turns of one No. 18 (.0403 in.) d.c.c. wire. *SF* equals 10.
Start winding—59 turns of one No. 30 (.0100 in.) d.s.c. wire. *SF* equals 10.
Both windings split skein-wound. Two-parallel connection.
Turns per pole—640 main and 590 starting. Starting turns 90 per cent of running turns.

Winding No. 10—For ¼-hp., 110-volt, 4.18-amp., 1,725-r.p.m., four-pole motor, 36 slots, 3⅝-in. bore, 1½ in. long.

Slot No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Main Winding	1/1	2	2	1			1	2	2	1/1	2	2	1			1	2	2	1/1
Start winding						2	1						1	2					

Main winding—37 turns of one No. 21 (.0285 in.) d.s.c. wire. *SF* equals 12.
Start winding—45 turns of one No. 26 (.0159 in.) d.s.c. wire. *SF* equals 6.
Turns per pole—444 main and 270 starting. Starting turns 60 per cent of running turns.
Both windings skein-wound. Two-parallel connection.

Winding No. 11—For ¼-hp., 110-volt, 1,700-r.p.m., 60-cycle, four-pole motor, 48 slots, 4-in. bore, 2 in. long.

Slot No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Main winding	1/1	2	2	1				1	2	2	2	1/1	2	2	2	1				1	2	2	2	1/1
Start winding						1/1	1	1								1	1	1/1						

Main winding—19 turns of one No. 19 (.0359 in.) d.s.c. wire. *SF* equals 16.
Start winding—30 turns of one No. 26 (.0159 in.) d.s.c. wire. *SF* equals 6.
Turns per pole—304 main and 180 starting. Starting turns 60 per cent of running turns.
Main winding hand-wound. Two-parallel connection.

Winding No. 12—For 1/3-hp., 110-volt, 1,725-r.p.m., 5.3-amp., 60-cycle, four-pole motor, 36 slots, 3⅞-in. bore, 2⅛ in. long.

Slot No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Main winding	1/1	2	2	1			1	2	2	1/1	2	2	1			1	2	2	1/1
Start winding						2	1						1	2					

Main winding—32 turns of one No. 20 (.032 in.) d.c.c. wire. *SF* equals 12.
Start winding—43 turns of one No. 26 (.0159 in.) d.s.c. wire. *SF* equals 6.
Turns per pole—384 main and 258 starting. Starting turns 67 per cent of running turns.
Main winding hand-wound. Two-parallel connection.

Table II—Winding Data for Fourteen Typical Single-Phase Motors Designed for 60-Cycle Circuits

(Continued from the preceding page)

Winding No. 13—For ½-hp., 110-volt, 1,750-r.p.m., 60-cycle, four-pole motor, 48 slots, 6⅜-in. bore, 2½ in. long.

Slot No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Main winding	1/1	2	2	2	1				1	2	2	2	1/1	2	2	2	1				1	2	2	2	1/1
Start winding							1/1	2	2	1						1	2	2	1/1						

Main winding—9 turns of one No. 14 d.c.c. wire. *SF* equals 16.
Starting winding—6 turns of one No. 23 d.c.c. wire. *SF* equals 12.
Turns per pole—144 main and 72 starting. Starting turns 50 per cent of running turns.
Both windings hand-wound. Parallel connection. Windings on rotor.

Winding No. 14—For 1-hp., 110/220-volt, 14.4/7.4-amp., 60-cycle, 1,740-r.p.m., four-pole motor, 48 slots, 5¼-in. bore, 2½ in. long.

Slot No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Main winding	1/1	2	2	2	1				1	2	2	2	1/1	2	2	2	1				1	2	2	2	1/1
Start winding							1/1	2	1								1	2	1/1						

Main winding—14 turns of two No. 18 d.c.c. wires in parallel. *SF* equals 16.
Start winding—18 turns of one No. 26 d.c.c. wire. *SF* equals 8.
Turns per pole—224 main and 144 starting. Starting turns 64 per cent of running turns.
Main winding hand-wound. Starting winding skein-wound. Connection: series for 220 volts and two-parallel for 110 volts.

two-pole windings, the turns per pole for the starting winding should not be less than 80 per cent of the running winding turns per pole.

For the starting winding, the turns per skein or per slot are found in the same way as already explained for the running winding.

By following out the methods explained in this article and studying the steps very closely, it will be found possible to take a three-phase or a two-phase core and calculate for it a single-phase winding that will give good results. On the other hand, a new winding can be worked out for a single-phase motor even when the original winding data are not known; or a starting winding can be designed for use with any main winding that may still be intact and in satisfactory condition.

Equipment Used to Apply Lubricants

(Continued from page 218)

turbines and other high-speed devices, and for similar applications. In some closed systems the bearings or gear faces are flooded with oil which not only lubricates but cools the bearing.

The lubricating systems mentioned above are typical in a general way of the various types of devices available. No attempt has been made to describe in detail the many common types of equipment coming under the first and second classifications previously mentioned.

The choice of a method of applying lubricant is dependent upon the type of lubricant used, the service and operating conditions, and the type of bearing.

From the descriptions which have been given of lubricating equipment, and an intimate knowledge of the operating and service conditions in their plants, it is hoped that industrial operating men may receive assistance in solving their lubrication problems. The manufacturer is always willing to give further advice or explanations in the application of his equipment to a particular problem encountered in the lubrication of industrial equipment.

The lubrication of motors will be discussed in an article which will appear in an early issue.

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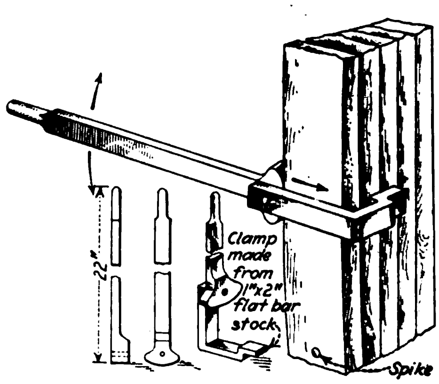
Clamp for Straightening Planks in Laminated Wall

A TYPE of a carpenter's clamp, which was used successfully to bend 2-in. by 6-in. planking edgewise in the construction of a sawdust fuel bin, is shown in an accompanying illustration.

The bin was constructed of 2-in. by 6-in. planks laid and nailed flat against each other, thus forming a laminated wall 6 in. thick. As some of the pieces were "snaky" some means of straightening them was necessary to make the wall smooth. The clamp shown in the sketches was made of 1-in. by 2-in. flat iron. The lever was 22 in. long and was made double thick on the working end which was rounded with a large radius to present a large bearing surface to the wood. The lever was fastened to the clamp with a ½-in. rivet.

The perspective drawing shows the clamp in operation. The lever may be moved in either direction according to the curved arrows. The head of the lever acts as a cam and forces the plank over in the direction of the solid arrow This device could be used on either side of the bin to force the planks into position before nailing. Planks with considerable curve were nailed on with the curve in one extending to the right and in the other to the left, so that they would compensate each other.



This clamp was used to force crooked planks in line when building up a laminated wall for a sawdust fuel bin.

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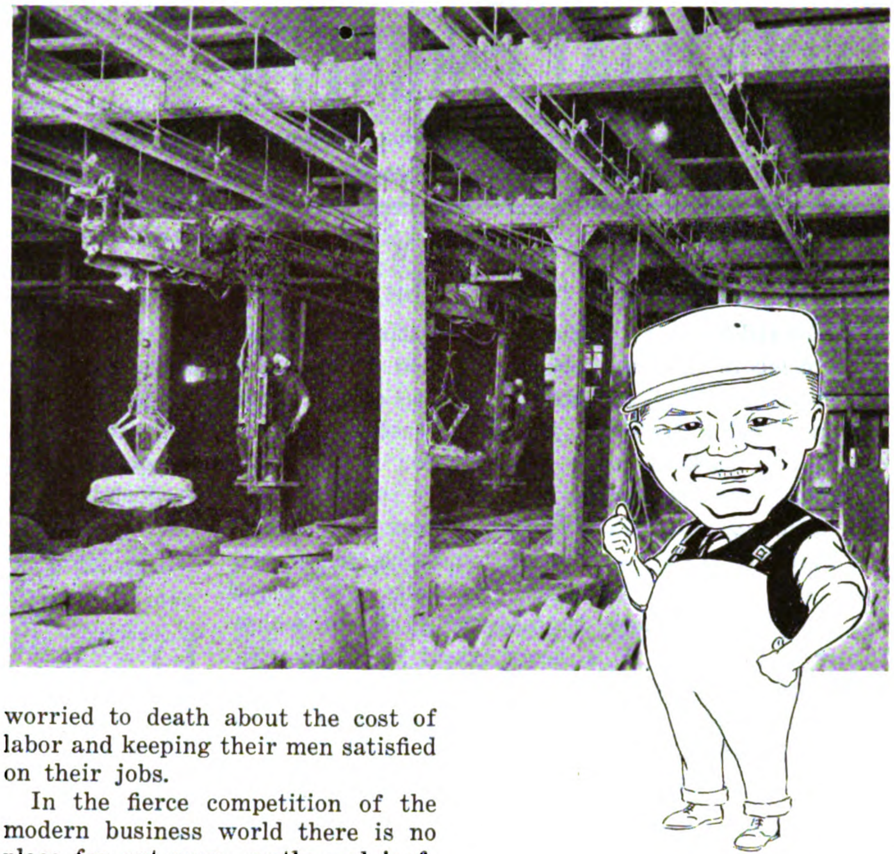
Lift and Carry Operations

can never be eliminated but they need not be the meanest jobs in your plant



STUDIES in production costs have worked great changes in handling operations in the up-to-date plants of today. The age of main strength and awkwardness in moving raw materials and semi-finished parts to and from machines has passed, and in its place can be found the results of brain work in speeding up operations and making handling jobs less dependent on a strong back and good right arm. The work expected nowadays from the day laborer, and the basis of his wage, is more on how he uses his head than his muscle; and so the many men who were once classified as day laborers are now expert machine operators who are happy and contented in doing their work, for which they receive a greater rate of pay, with less physical exertion, than was the case a comparatively few years ago.

One good example of this application of brain power to mechanical handling is shown in the accompanying picture, which shows two men handling awkward work. Under any other circumstances this would not be considered an attractive job and would call for a gang of men with a necessary supervisor to direct their operations. This picture plainly shows how the thinking of the individual responsible for the installation of this tramrail and hoist system effectively provided all necessary supervision of what to do and where to go in a simple mechanism that ordinary intelligence can learn to operate. The results are not hard to imagine in the speeding up of a hard job and making it attractive enough so that the hiring and firing of men to do the work is a problem that has almost been forgotten, as a thing of the past.

Such lift-and-carry systems are somewhat new to industry, but they have made such progress that today the plant that does not use them is among those that are struggling against competitive conditions and worried to death about the cost of labor and keeping their men satisfied on their jobs.

In the fierce competition of the modern business world there is no place for out-worn, costly and inefficient methods that may have been good enough in their time, and under different conditions than exist today, but which have been left behind in the swift march of industrial progress.

Strictly aside from the actual economies possible through the use of this equipment and the nice return that it will earn on the small amount of money it costs, I am calling this matter to your attention as a study in the handling of men. No plant superintendent or general foreman can afford to allow good, hard-working men to leave him after years of service and training simply because other plants provide easier work at the same rate of pay. The training of men is an expensive operation and it is worth something to keep them satisfied and happy on their jobs. Loyalty and a contented mind devoted to an honest day's work will always be reflected in the quality of product turned out and the cost of making it. But too often competitive conditions are blamed for fewer orders and less work in the plant, when a little time spent in studying hard jobs will disclose that the real trouble can be eliminated by reductions in production costs and the elimination of wasted time in back-breaking work that lift-and-carry systems can perform tirelessly and at insignificantly small cost.

As a superintendent you may be so close to your production problems that you are like the proverbial woodman who could never see the extent of the forest because of the trees. If you are in the midst of things so much every day that you are worried to death about plant production delays and slow deliveries, just take a vacation and visit some of the larger and newer plants where a new picture of production economies will come to you and you will go home and be able to show this to your boss in the light that will enable you to secure an authorization to make the needed changes in your plant to eliminate production worries. If you have to pay your own expenses on such a trip it will pay you in the end to do so, for you will get it all back some day in the reward that always comes to those who know how to relieve the boss of high operating costs and make business easier to get at a profit. After all this is as much a part of your job as making a good automobile, a good steam engine, a good monkey wrench or a good anything else.

Practical Pete

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

G. A. VAN BRUNT, Managing Editor

Do Not Forget the Days When You Were Starting Out

PROBABLY every industrial operating executive remembers the days when he started in the plant, either as "the kid," or directly from college to apply his engineering training. In either case he can, no doubt, look back at many rebuffs from some of his associates, and also carries appreciative remembrances of helpful suggestions and encouragement from others.

Frequently it is too late or impossible to reward those who assisted. However, practically every plant has its "kid" or new engineering graduate whose future is influenced to a large extent by those with whom he associates. Kind words and deeds cannot always be paid back, but they can be passed on to others who will appreciate and be helped by them.

Reduction of Factory Noise Is an Aid to Production and Employee Comfort

THE interest taken in employee welfare in the more progressive industrial plants is remarkable. This interest takes the form of improving the working conditions through making the surroundings more pleasant, providing better lunch rooms, recreation facilities and numerous other advantages. There is one thing, however, that is not receiving the attention that it should and which of all things has a great deal to do with the subconscious or nervous tension under which the employee works. We refer to noise.

There are many industrial processes where noise is unavoidable—forging, for instance, or the din found in a tack factory. On the other hand, there are noises that can be avoided. One of these is the annoying whine from a chain drive, which is due to no fault of the chain itself but is caused purely by maladjustment or faulty installation. Another noise is the nerve-racking din caused by poorly-aligned gears and pinions. Proper and periodic maintenance will reduce this greatly and the use of non-metallic gears will in many instances eradicate the troublesome noise. Another noise that is particularly distressing is that caused by whistles of high-pitch tone, such as found on yard switching locomotives, warning and mill signal whistles, call systems, and the like.

A high-pitch whistle that is sounded at frequent intervals causes a nervous tension that is not conducive to careful workmanship, while if the whistle is sounded at infrequent intervals, the nervous shock caused by the sudden blast is particularly trying. Use of low-pitch whistles will eliminate the nerve shock and at the same time the sound will carry further. If a low-pitch whistle is not desired, use may be made of some of the many types of electrically-operated automobile and signal horns now on the market. Also, some attention should be paid to the question of how far the sound or signal should carry. Only too often are the signals intended for only one department heard by plant departments at a considerable distance away.

Tremendous strides have been made in the use and application of improved factory lighting to eliminate eye strain with its consequent nerve strain and impaired production. Investigate the possibility of decreasing unnecessary and nerve-racking factory noises as a means of increasing the comfort of employees with consequent improvement in the quality and quantity of production.

Good Lighting in an Industrial Plant Costs Less Than Nothing

DURING the past few years the results of investigations have convinced the lighting expert that poor lighting is costly. He has found this out by proving that good lighting not only costs nothing, but usually yields a handsome profit on the investment. Those who are familiar with the manifold details of the scientific aspects of lighting and vision have predicted for many years that adequate and proper lighting would be very profitable to everyone.

The average intensity of illumination outdoors, under which our visual apparatus evolved, is a thousand times greater than the intensities commonly encountered indoors. There is every indication that illumination intensities upon our work-places and the brightness of the work are such that the eye is working in "low" instead of in "high," as it should for continuous use. The ability to see fine detail, distinguish differences in brightness, discriminate color contrasts, see quickly and accurately, work with safety, and keep up our spirits, increases as the intensity of illumination increases. Scientists know that this increase usually continues far beyond any intensities of illumination now provided by artificial lighting. Furthermore, light is so generally misused that visibility is decreased due to glare, shadows, great brightness-contrasts, reflected images of the light sources, and so on.

Investigations of the influence of lighting upon production in factories measure the combined effect of all these factors. Many investigations of this phase of production have shown an appreciable increase in production under improved lighting. Usually this increase is at least several times greater than the cost of the better lighting, which averages only 1 or 2 per cent of the payroll. Thus by placing good lighting on the payroll, it is safe to predict that it will always pay for itself and usually will net a profit of several hundred per cent.

Lighting experts claim that there are very few factories in the world in which improved lighting will not at least pay for itself.

Rules for the Safe Operation of Overhead Traveling Cranes

"SAFETY FIRST" has become a by-word in all industrial plants and careful investigations have discovered and eliminated many unsafe practices as a result. Even so, there is much to be done in the case of the overhead traveling crane.

The traveling crane is a source of accidents not only because the crane presents a hazard to those working underneath but also because it must be maintained, repaired, and operated from its overhead location. The overhead crane combines all the hazards of the freight elevator, the elevated electric car, and a railroad, with few of their safeguards. Safety has become more or less standardized for the three types of equipment just mentioned and accidents on them are few and far between. Such, however, is not the case with cranes.

At the present time, the Safety Division of the Association of Iron and Steel Electrical Engineers is collecting the safety rules now in effect in the various steel companies with the hope of formulating a set of safety rules that will cover all phases of the subject and materially aid in promoting safety in the operation of cranes. This action is to be commended and encouraged. It is hoped that the outcome of the work of this Association will be a standardized, working set of rules that may be universally applied to crane operation in all types of industrial works. Such rules are greatly needed and will prove to be of inestimable value.

The Size of the Junk Pile Is a Measure of Progress

DURING an interview reported in a recent issue of *Light*, published by the National Lamp Works of General Electric Company, Samuel Insull, one of the outstanding figures in the central station field, was asked what he considered to be the most valuable asset of the lighting and power industry.

"The junk pile," was his answer. Then he added, in explanation, "The junk pile indicates how quickly an industry can learn."

In these few words Mr. Insull expressed a truth that means a great deal to every industrial plant executive. In far too many industrial plants there are in operation today scores of machines and other equipment that should have been junked long ago. Good in its day—perhaps it was the best that could be had—this equipment is now obsolete and inefficient, a potential source of trouble from breakdowns, and a hindrance to maximum production. Methods and processes that have been discarded by progressive plants, inefficient equipment, and high operating and maintenance costs do not make for high quality and quantity of products, at low unit cost.

Nor is the personal application of this truth hard to make. How many of us are held back from the advancement that we might obtain, by our tenacious adherence to out-worn ideas, antiquated notions and stubborn belief that the way we always have done certain things is necessarily the best way to do them? After all, growth and advancement in a professional and intellectual way are simply the acquisition of new facts and new knowledge, and the discarding of ideas and practices that have been shown to be erroneous or have been superseded by ideas and practices that are better adapted to present-day conditions.

Check over your mental junk pile and see how many additions you have made to it, say, during the past five years. By so doing you may find that you could, with profit, increase the size of that junk pile considerably.

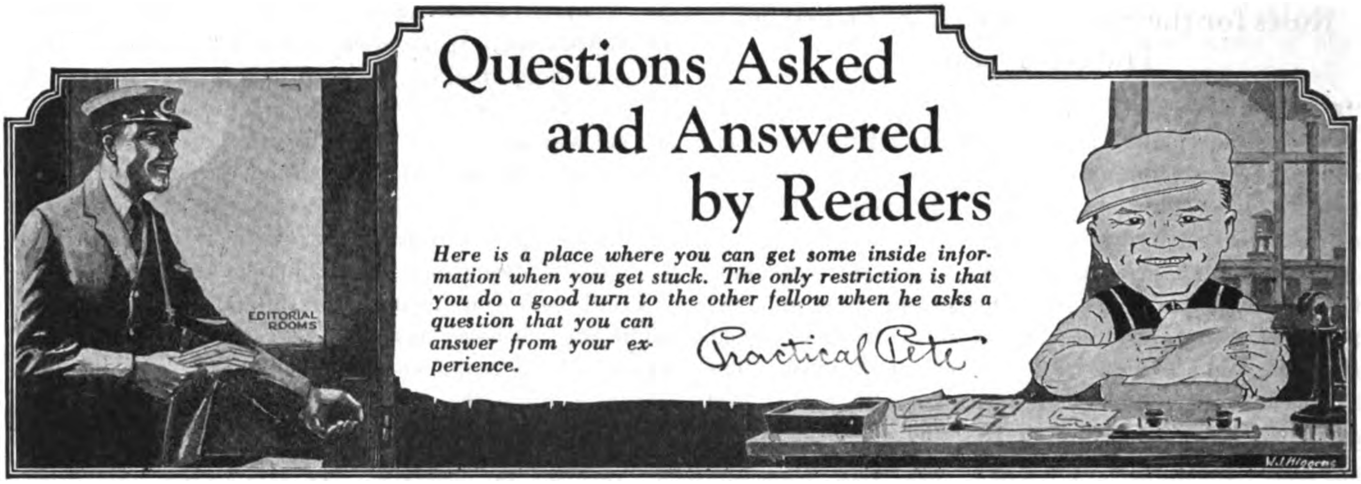
Do Not Let Whims Be Your Guide in Laying Out Power Drives

COWHIDE in the form of leather belting has been with us for a long time. Volumes of engineering data can be found on its use and methods of application, all based on years of performance; and yet there are plenty of improper applications of otherwise good belts in almost any large plant, new or old, that you may visit today. You will find too long centers, too short centers, wrong pulley ratios, wrong belt widths, light-weight belts used where doubles should be used, and large and small doubles with home-made or makeshift belt tighteners and other such contraptions that are evidence of bungled drive design or corrections of mistakes that could have been avoided by the proper use of belt data to be found in any good mechanical engineering handbook.

Because belts have been so generally used and every plant man has taken a hand in applying them according to his own ideas, or according to space restrictions imposed by someone whose power drive knowledge or experience is still in the kindergarten stages, there have sprung up the many cure-alls for belt applications and troubles.

We hold no particular brief for the leather belt, simply because it needs no defender. It has made a place for itself through years of service under favorable and unfavorable conditions, and although the whims of drive designers to do away with belts must be expected to come and go in the future as they have in the past few years, the belt drive will be with us for a long time to come, simply because there is a limit to complications in machine drives, so that cost alone and the competition and simplicity of a well-laid-out belt drive will be the deciding factors.

To our readers who are responsible for plant operating costs, we offer the suggestion that a few hours' study of such data on belt and power drives as are contained in Kent or Marks or any other good handbook will provide plenty of food for thought on how to save money in their own plants. Belt slip, belt stretch and the burning of belts over driving pulleys have reasons for which ignorance and belt dressing are not the corrective remedies.



Who Can Answer These?

Wiping Lead Joints in Lead-Sheath Cable.—I should like to have readers give me some information on how to go about wiping joints in lead-covered, three-conductor, 2,300-volt cable. I should like to know how to prepare the joint for wiping, what materials should be used, how to wipe the joint, and any precautions that should be observed in wiping the joint.
Benoit, Ala. G. E. W.

* * * *

Demagnetizing a Lathe.—I have a 24-in. by 10-in. selective head lathe, which is magnetized; at least, when any work is done on the lathe, the chips cause us trouble by sticking to the lathe tool and surrounding lathe parts. It is my opinion that the spindle of the lathe is magnetized. I shall greatly appreciate it if readers will tell me how to demagnetize this lathe. If it is necessary to use a demagnetizing coil, how big should the coil be, how many turns and what size of wire should be used? Also, how many amperes should flow through the coil? Is there any way that I can demagnetize this lathe without using a demagnetizing coil?
Beaumont, Tex. O. C. B.

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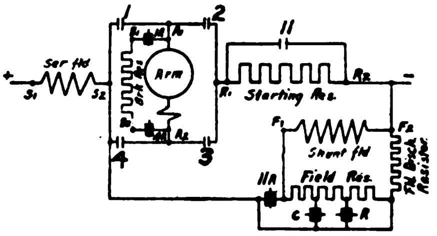
Best Way to Install Ball Bearings in Lineshaft Hangers.—We are going to replace the split, babbitted, shaft-hanger bearings on a $2\frac{7}{16}$-in., 72-ft. shaft with new ball bearings. The same drop hangers are to be used. Two solid pulleys are used; the remainder are split, either wood or steel. The shafts are connected with keyed flange couplings. What is the best way to go about making the change? Would it be best to let the shaft down to the floor, or work overhead? What is the easiest way of getting the flanges off and on again? Would it be better to replace them with compression couplings?
Syracuse, N. Y. H. L. G.

* * * *

Changing Control to Obtain Lower Motor Speed.—The motor on our reversing planer drive is a 10-hp., Westinghouse, frame 90, type SK, shunt-wound motor having a speed range of 250 to 1,000 r.p.m. We have no spare for this motor and when it fails, it is necessary to substitute a 15-hp., 400/1,600-r.p.m., type SK Westinghouse, shunt-wound motor. The automatic control on the planer drive is arranged as shown in the accompanying diagram. The sequence of operation of the contactors is shown in the table. In this tabulation the number of the contactor is given in the left-hand column, the "Cut" column refers to the cut stroke, the "Return" column refers to the return stroke, and the "Bk." column refers to the dynamic braking applied between reversals. The control is arranged so that a low speed is used on the cutting stroke and a high speed on the return stroke. These speeds are obtained by proper adjustment of the shunt-field rheostat. When using the 400/1,600-r.p.m., 15-hp. motor, the speed of the return stroke can be properly adjusted, but the cutting stroke is too fast. Full field on the motor gives 400 r.p.m., whereas a speed of approximately 300 r.p.m. is



Sequence of Contactors

Con.	Cut		Bk.	Off.	Bk.	Return	
1						O	O
2	O	O					
3						O	O
4	O	O					
11	O						O
1A	O	O	O	O	O		
4A			O	O	O	O	O
11A		O	O	O	O	O	

desired. Can readers tell me any way that I can obtain this speed on the 15-hp. motor without rewinding it or changing its fields? Is it possible to obtain satisfactory results with resistance in series or in parallel with the armature? If so how much resistance should be used, or how should I go about determining the correct amount?
Indiana Harbor, Ind. A. R. D.

* * * *

Method of Connecting Generator to Bus.—In the power house of our lumber mills we are planning on installing a 6,000-kw. three-phase, 480-volt, 9,000-amp. turbo-generator. To the bus there are now connected an 800-kw. and a 2,000-kw., 480-volt generator. I would like to know what readers would recommend for connecting the 6,000-kw. generator to the bus. Should cable be used, and if so, how should it be arranged so as to eliminate the inductive effect and its consequent heating due to the heavy current flowing? Would it be better to use bus-bars and if so, how should they be supported and arranged so as to reduce the induction? Any recommendation that readers can give for the layout of the connection between the generator and bus will be appreciated.
Bellingham, Wash. E. M. D.

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Changing Wire Insulation.—I am planning to rewind the armature of an Autolite generator. This armature was originally wound with No. 18 single-cotton-covered wire. Can some of the readers of this column inform me what results I will get if I rewind this armature with No. 18 enameled wire? I shall be grateful for your help.
Marietta, Ohio. E. L. W.

Proper Foundation for Alternator.—(1) We are going to install a 133-kva., belt-driven alternator in the near future, and I should like to know how to make a suitable foundation for it. We are thinking of using a wooden framework. Is this alternator too large for such a foundation? I should like to know what type of foundation readers would recommend for this alternator, and also how the foundation should be made. (2) When the distance between pulley centers of the alternator and engine is long should the alternator foundation be heavier than when the machines are close together? How should the alternator be fastened to the timbers or other types of foundations that are recommended? I shall greatly appreciate any information that readers can give.
New Orleans, La. O. C. H.

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Trouble From Static on Belt-Driven Machines.—We have about 200 sewing machines all of which are belt driven. The girls who run these machines complain that they frequently get shocks from them. I believe that this is due to static from the leather belts which drive the sewing machines. I shall appreciate it very much if some reader can tell me how to prevent this trouble. I have grounded the sewing machines but the trouble still continues. To what should I ground the machines so as to obtain the best results? How should the ground be made? I might say that the sewing machines are placed on wood floors in a room that is quite dry and warm. Would the use of rubber belts correct the trouble I am encountering? I should like to learn the experience of other readers on this subject.
York, Pa. P. C.

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Answers Received To Questions Asked

Selecting High-Pressure Bearings.—In one of our manufacturing processes the product is rolled under high pressure. We have always had considerable difficulty with the bearings and as we are going to rebuild the machines are considering installing other types of bearings. I would like to know what types of bearings other operating men favor for paper calendars, rubber mills, and cereal rolls, as I believe our problem is similar. Will some readers from these industries please give me their experience with babbitt (including the type), bronze bushings, ball or roller bearings and the method of lubrication which they have found most satisfactory?
Brooklyn, N. Y. J. A. A.

A high-pressure bearing of the type J. A. A. is considering should be of a design to provide automatic lubrication, and of such proportions that the pressure per square inch of projected area is within the limit of the load-carrying capacity of the bearing metal.

The bearing metal should be softer than the metal of the journal so that a minimum of injury would result from seizing. Other desirable properties are: a low co-efficient of friction, a low co-efficient of expansion, high heat conductivity, the property of adhesion, to hold the oil film, the ability to carry intermittent overloads, and the ability to withstand abnormal bearing temperatures. The soft alloy bearing metals yield to the contour of the journal under heavy loads and increased temperatures, which decreases the pressure on the high spots, re-establishes the oil films and so prevents the seizing of the journal. The harder metals, such as bronze and brass, according to my experience, do not have these advantages or possess the most desirable characteristics mentioned.

Genuine babbitt has been used successfully for heavy duty in properly-designed bearings, but I have found under test and actual working conditions in the field that a similar white metal known as Bearite, which is manufactured by the A. W. Cadman Co., is an exceptional bearing metal. This metal can be used in bearings with pressures from 150 lb. to 300 lb. per inch of projected area, with corresponding temperature rises of 70 and 130 deg. F. respectively in the bearing, with peripheral journal speeds of 300 to 1,100 f.p.m.

In the absence of definite data as to speed, load, physical limitations, and the nature of service, no definite proportions or design can be given to J. A. A. The length of the bearing in terms of the diameter, varies according to the nature of the load and the type of bearing. For heavy journals with fixed bearings, the length is from two to three times the diameter of the journal.

E. H. LAABS.

Engineer,
The Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

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Misleading Results Sometimes Obtained from Magneto Test.—Sometimes I get rather misleading results through the use of a magneto to determine whether there are defects in some of our electrical apparatus. Under certain conditions I have found that the magneto will indicate a dead ground, whereas further investigation shows that the equipment is in very good operating condition. Also, I have found that a magneto will sometimes indicate an open in a shunt-field coil, when further investigation shows that the field coil is O. K. I should like to know if any readers have had similar experiences and can explain the reasons for this peculiar action of the magneto. Also, can you suggest other test methods that might be used under the conditions mentioned?

Omaha, Neb. M. P.

In answer to the question asked by M. P., I have found that the use of a magneto for testing is not advisable in a number of instances. With the exception of a few special types, the magneto generates an alternating current. When used in testing a shunt field, or any highly inductive winding, the choking effect of the inductance limits the current to less than that required to ring the magneto bell. This will cause the magneto to indicate an open circuit when the circuit is closed. When testing a line for grounds the capacity of a long line is often so great that the charging current will be sufficient to ring the magneto bell, indicating a ground when the line is actually clear.

An instrument that I find very handy for making a number of different tests is a Weston, model 45, direct-current voltmeter, having four ranges, 3, 15, 150 and 300 volts. This instrument is very sensitive, having a resistance of 108.38 ohms per volt. It is shielded against stray magnetic fields by an iron case which is enclosed in a substantial wood carrying case, making a very rugged instrument that will stand a lot of external abuse.

In testing for grounds or opens, I use the 3-volt range and two dry cells. This will give a positive indication through a fairly high resistance. The deflection of the pointer of the meter when connected through a resistance of 50,000 ohms is about one scale division. With a lower resistance you get a correspondingly greater deflection. In case of an open, the voltmeter will give no deflection; that is, zero voltage. In case of a short or dead ground, the voltmeter will indicate full battery voltage or 3 volts.

By using the voltmeter method of measuring insulation resistance, measurements of insulation resistance can be made up to as high as 9 megohms when using the 300-volt range on the voltmeter and a 220-volt power supply. In making insulation tests where direct-current power supply line is not available, I have five of the small size 22½ volt, radio B batteries mounted in a carrying case. This gives me about 110 volts. These batteries can be purchased for about 65c each and with reasonable care will last a year or more. Using this set of batteries and the 150-volt range on the voltmeter, a deflection of one scale division will read 1.8 megohms.

By using the various ranges of this instrument and a corresponding voltage, resistance can be measured fairly accurately down to about 10 ohms. This instrument is also useful in testing armatures for opens, shorts or grounds, for checking sets of shunt coils for partial short-circuits, and in setting brushes. It is also useful in testing the voltage of individual cells or groups of cells of storage batteries.

WM. H. FREDRICKSON.

Elizabeth, N. J.

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Regarding the misleading results obtained by M. P. in his magneto test, I would say that a magneto should not be used for testing for grounds on large coils, on long cable circuits, or between circuits of large electrostatic capacity, because of the condenser effect, which may indicate a physical connection where none but a condenser connection exists. A lamp test using alternating-current supply, the telephone receiver test, and the voltmeter test where the voltmeter is used on alternating current, all have limitations similar to those of the magneto.

In testing for a continuous circuit in a field coil, a telephone receiver in series with a worn-out flashlight cell will give a good, live click when placed across the terminals of the coil under suspicion, if the circuit is not open. Also, in ordinary cases, the lamp test is reliable where the coils do not have too high resistance.

For ground tests, my experience as a trouble man during years of attention to details, leads me to state that for practically all ordinary cases, the voltmeter test for grounds is reliable, when direct-current supply is used for testing instead of alternating current.

Windsor, Canada. L. L. FARRAR.

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The use of a magneto in testing electrical apparatus should be carried out with caution. This is due to the fact that the magneto generates alternating current and is subject, therefore, to the effect of inductance and capacity in the windings. For instance, if there is considerable capacity between windings and ground, sufficient current will flow in the circuit (made up of one terminal of the apparatus and the other connected to the frame of machine) to cause the magneto bell to give a slight ring and apparently indicate to the tester that a ground exists. This is an alternating-current phenomenon which is readily observed in power transmission circuits where ammeters will give a reading at the generating station even though the circuit is open at the receiving end of the line. This current is commonly known as charging current.

It is often found in trying to ring through a highly inductive winding, that is, one of many turns, as a high-voltage winding on a transformer, that the magneto bell will not ring; this remark is also applicable to a shunt-field coil. This is due to the fact that the impedance of the winding is so high that the magneto generator is not capable of forcing sufficient current through the winding to allow the bell to ring. In other words, to an inexperienced tester an open circuit would apparently exist when the circuit was actually intact.

There are several methods of testing that may be used, all of which are based on using direct current in some way. The following methods are in common use: (1) An outfit consisting of dry batteries and a bell or buzzer. (2) A test set consisting of dry batteries and some form of commercial galvanometer. (3) A lamp bank. (4) A Megger testing set.

Methods 1, 2, and 3 are in common use. The exact number of batteries required for the first two methods, of course, depends on the type of equipment being tested. A number of commercial forms of galvanometers can be purchased on the open market in various forms and under various trade names. The use of a megger outfit for general testing is becoming very common, as the outfit may be adjusted to suit various conditions. In general it may be said that methods 2, 3, and 4 are to be preferred since the result or effect may be seen by the eye while the effect of method 1 is on the ear, which may be, and usually is, not so sensitive as the eye.

A very delicate test consists in using a telephone headset and a dry battery. This test is used in underground cable

work quite extensively for testing for grounds, short-circuits and continuity. It is necessary, however, that the tester should not be deceived when testing for an open circuit if the circuit has much capacity, since a click may be noted when the circuit is first made, due to the current necessary to charge the system. A little practice, however, will overcome the objection to this method which is readily applied and requires very little equipment for using it. C. OTTO VON DANNENBERG.

Designing Engineer,
Sanderson & Porter,
Springdale, Pa.

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The problem on the action of a magneto, given by M. P., could be answered more completely if the resistance of the ringer were known, and also the types and voltages of the coils and equipment being tested.

Magnetos will often give misleading results on inductive circuits due to the induction set up in the circuit by the alternating current from the magneto. The induction in the circuit varies with the frequency of the magneto and the current flowing through the circuit under test is governed by the resistance and inductance in the circuit. The faster the magneto is turned, the higher the frequency and inductance become. Even though the voltage of the magneto increases with the speed, the inductance may be great enough to reduce the current.

A low-resistance ringer used for testing requires a higher current than one of high resistance. Testing a high-voltage, high-resistance, field coil with a low-resistance ringer may not permit sufficient current to flow in the circuit to operate the ringer, due to the high inductance and resistance in the coil retarding the current. Yet, this same coil tested with a high-resistance ringer may pass enough current to operate the ringer with the same voltage and frequency. In this way, an open-circuit may be thought to exist in the coil. A coil with a large number of turns and which has an open circuit may give a ring with a high-resistance test set if the break is near the center of the winding. The condenser effect between the two parts of the winding may pass enough current to operate the ringer.

Making a ground test with a high-resistance magneto may indicate a ground which would not show up on low-resistance testing equipment. The ground may be a high-resistance one and yet pass sufficient current to operate the ringer, but be of too high resistance to pass enough current to burn out on a low-voltage test. Ground tests should be made with a low-resistance device, but a high-resistance test is good also to prove that no kind of ground exists. It is advisable to make a high-resistance ground test on appliances that are to be handled by inexperienced persons, for a current strong enough to be felt may pass through a ground of this nature.

The use of a magneto for testing should be confined to non-inductive circuits, such as resistance units and other apparatus. Coils may be tested with good results by removing them from their cores, since this reduces the inductance and will permit more current to flow through them with the same voltage applied. Windings with iron cores act the same as any a.c. choke coil even though they may be designed for d.c. operation.

The Electric Fault Finder made by The Electric Controller and Mfg. Co., Cleveland, Ohio, gives splendid results for testing all kinds of equipment. It does not use a magneto, thereby doing away with the frequency and induction effects in circuits under test. I have used it in all kinds of tests and find it entirely satisfactory. I also find the Megger to be one of the most reliable testing instruments as it reads directly in ohms which enables the repairman to compare the condition of the coils under test with standards. The "Meg" is advertised on page 98 of the March issue of INDUSTRIAL ENGINEER by James G. Biddle Co., Philadelphia, Pa. M. P. will make no mistake in securing either one of the instruments I have mentioned if he has much testing to do.

Chicago, Ill. CARL G. HOWARD.

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Replying to M. P.'s question, I quite agree with his remarks about the results he obtained from testing with a magneto. I also notice that in the January, 1926, issue on page 40, R. N. Vining made similar remarks about the magneto in his article on "Method of Testing for Grounds and Faulty Insulation." Since he did not give the reason for the results obtained with a magneto, which M. P. asks about, I will endeavor to answer his questions.

Among available testing apparatus which we may mention beside the magneto are, the telephone receiver and battery, the vibrating bell or buzzer and battery, the test lamp using d. c. or a. c., the voltmeter and ammeter, and test sets put out by various companies. The one which comes to my mind first is that of the Square D Company, which will indicate a value of a. c. or d. c. roughly, up to 600 volts, distinguishing between these currents and doing almost anything except indicating the polarity of d. c. circuits.

In circuits which we are called upon to test there is the quality of resistance which limits the flow of both d. c. and a. c. according to Ohm's law. Also, every commercial circuit possesses in some degree a quality known as inductance. This quality becomes more apparent if the wire of the circuit is wound on a spool or a coil, and is of greatest value when this coil has a core of iron or soft steel as in the case of a field coil of a d. c. machine or the winding of a transformer. As the current changes in value in a circuit having inductance, a counter-emf. is induced in the circuit which prevents the current from flowing as it would in a circuit in which resistance alone is present. In a d. c. circuit, the current is continuous; therefore, inductance does not materially affect a circuit through which a direct current flows. In an a. c. circuit the value of the current is changing constantly as well as reversing in direction so that inductance will have considerable effect.

A magneto is usually able to ring its bell through 25,000 to 40,000 ohms of resistance, but when we test a circuit of high inductance even though the resistance may be very low, especially so in the case of a primary of a transformer or the field coil of a d. c. machine, the bell may not ring due to the fact that the magneto generates alternating current instead of direct current, for the magneto is a two-pole, a. c. generator with permanent magnets to suply the excitation.

The opposite quality to inductance is capacity or condenser effect, which is also present to some degree in all circuits and to a marked degree in any circuit of considerable length. When testing with a magneto on a wire having considerable capacity connected to it, we may obtain a ring, indicating that the circuit is not open. However, when testing the same circuit with a high-resistance, d. c. voltmeter and a voltage of say 110 volts direct current, the voltmeter reading will indicate an open or zero voltage, outside of a "kick" of the pointer when the circuit is first made. If we add to this voltmeter circuit a reversing key, which will put first the positive side and then the negative side of the direct-current supply to the terminal of the insulated wires, we will get a "kick" each time we operate the reversing key and if we do it fast enough, the voltmeter indication will be the same as if a small voltage of varying value were acting on the line under test. What we are doing is actually putting a. c. into the line, or charging and discharging the condenser which the line constitutes.

The magneto, also, will send a current through, or more correctly, will charge and discharge this condenser and when we remember the very small current necessary to ring the bell or buzzer it is evident that it does not take much of a condenser to have an "apparent resistance" below 25,000 or 40,000 ohms, or low enough to give us a signal.

Electrical Foreman, L. E. DUNHAM.
The Sydney E. Junkins Co. B. C. Ltd.,
Vancouver, B. C., Can.

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In answering the question asked by M. P., it will be interesting for him to know that a magneto test set should never be used for testing field poles of an electric machine, nor any coil having a number of turns of wire wound upon an iron core. Also an electric circuit of great length should not be tested with the magneto. If a circuit of high capacitance is tested with a magneto test set an erroneous indication may be the result, due to the electrostatic capacity of the circuit and the alternating current of the magneto alternately charging the two conductors to positive and negative potentials, causing the bell to ring, and thereby indicating a short-circuit where none exists. The shunt-field coils of a direct-current motor or generator have a high inductance and when testing the coils with the magneto, the bell may not ring, thereby indicating an open circuit, although the circuit may be closed. The reason why the bell does not ring even though the circuit is not open, is

because of the high impedance of the inductive winding of the field coil to the flow of alternating current from the magneto. The result is that not enough current flows through the magneto to ring the bell.

In the absence of a voltmeter or testing transformer, a grounded coil can be located by the lamp test. A 60-watt or larger lamp connected in series with the coils under test, will act as an indicator and also will prevent excessive current flow. To test for grounded coils proceed as follows: Disconnect the machine from the line; connect one side of the line to one terminal of the field coils, then connect the other side of the line to the frame of the machine. If one of the coils is grounded, the lamp will light. The exact coil that is grounded may be located by opening connections between the coils so as to divide them into groups. Each group should then be tested separately for grounds. After the group with the ground has been found, open the connection between each individual coil in this group and test each coil for a ground. By using a testing transformer the exact location of the ground can be located by the smoke, arc, or heating where the ground exists. OVIDE C. HARRIS.
Plant Electrician,
Freiburg Mahogany Co.,
New Orleans, La.

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Starting Large Induction Motors.—The local power company does not permit the connection of squirrel-cage motors larger than 25-hp. capacity to its line. Above this size a wound-rotor induction motor is required. Such a motor and its control are of necessity more expensive. It is my understanding that some forms of resistance starters for squirrel-cage motors will cause the initial current peak to build up gradually and consequently create no voltage disturbance on the power company's lines. If any readers have used such starters on motors larger than 25 hp., so as to meet the requirements of power companies and have successfully shown them that motors larger than 25 hp. can be started without line disturbance, I would greatly appreciate learning the details of the application. I would also like to learn the motor size, voltage, speed of motor, and type and maker of starter in each case.
Cedar Rapids, Ia. H. P.

H. P. will be able to obtain the data that he wishes regarding the starting of large induction motors, from such companies as the Century Electric Co., St. Louis, Mo., the Wagner Electric Corporation, also of St. Louis, Mo., and the United States Electric Co., Los Angeles, Calif. The Century type AS motor is made in capacities up to 60 hp. while the Wagner type BW is made up to 50 hp.

The Wagner motor has a winding in the rotor that causes the motor to take low starting current. This winding is shorted when the motor comes up to full speed and the motor runs as a squirrel-cage machine. The Century motor is similar to the Wagner type except that it has a buried squirrel-cage winding which does not function until the motor reaches nearly full speed. The United States Electric motor has both windings, but uses a heavier squirrel-cage winding and does not short the wound-rotor winding. Other companies are adopting this latter scheme. These manufacturers will supply for their motors, data as to the starting current at full load, time of acceleration, and the like.
Seattle, Wash. W. MONTELIUS PRICE.

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Low-Voltage Generator Will Not Excite.—It was necessary to rewind the shunt field coils of a 50-volt generator of very low capacity, which is direct-connected to a small motor having a speed of about 4,000 r.p.m. It is a two-pole machine having 2,000 turns of No. 37 wire in each shunt field coil. When the winding was completed, the machine generated 55 volts satisfactorily. It was then found necessary to reverse the generator position with regard to the motor, which of necessity reversed the direction of rotation; due to this reversal of rotation the residual magnetism of the generator was lost. When I separately excite the shunt fields from a 50-volt, direct-current bus the generator develops its proper voltage. When I reconnect the fields to the armature terminals I get a reading of only 1 volt. I wish some reader would tell me what is wrong and how I can correct this trouble.
Stamford, Conn. W. E. H.

With reference to W. E. H.'s trouble, the diagrams in the accompanying illustration will show what is happening to his machine and how to remedy the trouble he is experiencing with his generator.

Diagram *A* shows the original conditions for a self-excited generator rotating clockwise, having the right-hand brush positive. The curved arrow indicates the direction of rotation of the armature and the straight arrow in the small circle indicates the direction of current flow in the armature of the generator.

When the direction of rotation of the armature is reversed by turning the generator around 180 deg., this would change the polarity at the brushes, if the field strength could be maintained in its original direction. In diagram *B*, the direction of rotation has been changed to counter-clockwise to correspond with the conditions just stated. This changes the current flow through the armature and also the brush polarity. What happens in this case is that when the generator is started from rest, the pole pieces retain a small amount of residual magnetism of the original polarity and when the armature starts to revolve the residual magnetism generates a current in the armature conductors which flows in the opposite direction to the original current shown in diagram *A*. This results in the armature generating a voltage of the opposite polarity and inasmuch as the fields are connected directly across the armature, the reversal of polarity causes the field current to flow in the opposite direction through the field coils. This current tends to build up the field in the opposite direction and the result is that the magnetomotive force caused by the field current opposes the residual magnetomotive force so that the sum total is zero, the fields are demagnetized and no voltage is generated. In other words, the generator does not build up its voltage.

Now, when the fields are separately excited, the machine will generate regardless of the polarity of the pole pieces and the polarity of the brushes will depend upon the direction of current in the field. This condition is shown in diagram *C*. If the field is separately excited in the same direction shown in diagram *B*, the generator will build up its voltage when self-excited again. However, if the shunt field is separately excited in the oposite direction to that shown in diagram *B*, the generator will not build up its voltage when self-excited again.

There are two ways by which the machine can be made to pick up its voltage. One method is shown in diagram *D*. In this case the shunt field leads are interchanged, which gives the original polarity but changes the brush and busbar polarity. If it is required to retain the same busbar polarity, the armature leads can be interchanged as shown in diagram *E*, which would give the same conditions as the original set-up.
Wilkinsburg, Pa. A. C. ROE.

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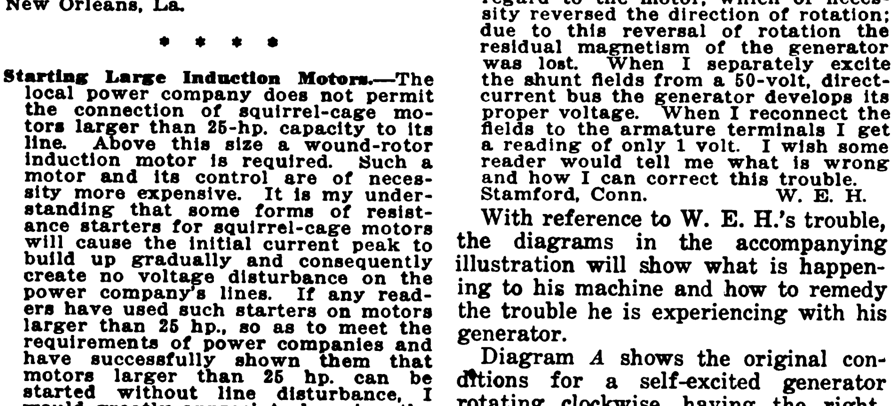
In answer to the question asked by W. E. H., I would say that in order to obtain residual magnetism in the field poles in case there is none, excite the shunt field from an outside source of power leaving the current on long enough so that the field poles will attract soft iron held adjacent to the poles. If the current from the armature is flowing through the shunt field in the right direction to strengthen the residual magnetism in the field this, in turn, will result in a greater voltage being generated which will cause a greater field current. This process goes on until the machine is generating its rated voltage. On the other hand, if the shunt-field current is in such a direction as to set up a magnetomotive force bucking the residual magnetism of the fields, the field is weakened to



These diagrams show in detail the cause of the trouble experienced by W. E. H. with his 55-volt generator.

such an extent that the machine will not build up.

If the machine will not build up or excite, due to the cause mentioned above, namely wrong direction of shunt-field current, there are three ways of getting it to build up. The first way is to reverse the shunt-field leads to the armature. A second method is to reverse the direction of rotation. The third way is to reverse the direction of the separate source of exciting current through the shunt field. The way to accomplish the first is apparent. As to the second, if the direction of rotation cannot be reversed it need not be considered. By the third method, a residual magnetism may be built up in the field core with the same polarity as that produced by the armature current, after the direction of rotation has been reversed.

Note that reversing the shunt field leads to the armature reverses the direction of the current through the shunt field. This enables the current to strengthen instead of weaken the field. The strong field in turn causes the machine to build up, as has been explained.

Concord, Mass. DONALD FERGUSON.

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W. E. H. asks about the cause of some trouble he is having with a small generator building up after the direction of rotation was reversed. When the machine was turned around and the direction of rotation reversed, he should have either crossed or interchanged his armature leads or his field leads in order to get it to generate. After he has done this the generator may have the oposite polarity, due to the fact that he has separately excited the fields from an outside source. If this is true and it is necessary to reverse the polarity all that he need do is to excite the fields from the busbars again, connecting the field leads to the oposite busbars.

Peoria, Ill. GEO. RINGNESS.

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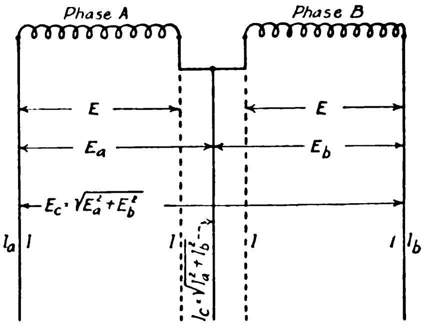
Method of Changing Two-Phase, Four-Wire System to Two-Phase Three-Wire System.—Our power supply is from a two-phase, four-wire system. For various reasons I wish to change the distribution to a two-phase, three-wire system. Will some reader tell me how to determine which wires of the four-wire system should be connected together to form the common or neutral wire? Is it possible to tie together the wrong pair of wires to form the neutral? How should the four-wire, two-phase motors be connected to the three-wire system? Are there any precautions to take in connecting motors to the three-wire system? Will this change affect anything else in the plant?

New York, N. Y. J. M.

Answering J. M. I would say that there are several factors that should be taken into consideration in changing from a two-phase, four-wire system to a two-phase, three-wire system. In determining the proper wires to connect together for the neutral wire, many machines are designed with the phase wires of phase A and phase B in rotation on the terminal block; that is, phase A leads will be numbered 1 and 2 and the wires of phase B will be numbered 3 and 4. Since it is desired to connect the two phases in series, it will be necessary to connect wires 2 and 3 together, the center wire for the system being taken from this series tie. It is entirely possible to connect the wrong wires because connecting 1 and 2 or 3 and 4 together would cause one phase of the machine to be short-circuited.

The current and voltage relations in a two-phase, four-wire system may be determined by treating each circuit separately, as if they were two individual, single-phase circuits. However, when the system is transformed from a two-phase, four-wire circuit to a two-phase, three-wire circuit, the treatment



Comparative current and voltage relations in four-wire and three-wire, two-phase systems.

becomes more complicated. When the system has been changed from a two-phase, four-wire to a two-phase, three-wire, the phase voltages are added vectorially to find the voltage across the outside wires. This is found to be equal to the square root of the sum of the squares of the phase voltages, as, E_c (voltage across outside wires) $= \sqrt{(E_a^2+E_b^2)}$ as is shown in the accompanying diagram. A similar relation holds true for the current in the common wire. Let I=the current in each phase for the four-wire system, as shown in the accompanying diagram, and I_a and I_b equal the current in the A and B phases respectively for the three-wire system. Then $I=I_a=I_b$. Also, $I_c=\sqrt{(I_a^2+I_b^2)}$, equals the current in the common wire as is shown in the diagram. PHIL D. COMER.

San Bernardino, Calif.

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I assume that the power supply in J. M.'s plant is 220 volts and that he is going to make the change from two-phase, four-wire to two-phase, three-wire on the main distribution board. It is then a question of determining which two of the four terminals on the board can be connected together to form the neutral. The voltage should be measured across any two of the four buses or terminals. He should locate a pair of terminals that show no voltage across them. These can be connected together to form the common wire. After making this connection the voltage across the remaining pair of terminals should be 310 as read from the voltmeter. These two terminals will connect to the two outside wires of the three-wire system. If J. M. applies this test he will have no difficulty in connecting the correct pair of wires together.

In a two-phase system, one phase is 90 deg. ahead or behind the other phase. This means that at a certain instant of time, one phase generates maximum voltage while the other phase generates zero voltage. Now with one terminal of each phase connected together and measuring the voltage across the remaining terminals of each phase, the two phases will be connected in series across the voltmeter. The voltage across the two phases in series, 90 deg. apart in time phase, will be equal to the square root of the sum of the squares of the phase voltages or $\sqrt{(220^2+220^2)}=310$ volts.

The leads of two-phase motors are generally marked T-1 and T-3 for one phase and T-2 and T-4 for the leads of the other phase. So, by connecting T-3 and T-2 together to form the common wire and connecting T-1 and T-4 to the outside legs of the three-wire system, J. M. will solve the problem of connecting the motors. If the rotation of the motors has to be changed, reverse the leads of only one phase at the motor.

When changing over from a four-wire to a three-wire system, J. M. will have to consider the voltage to ground on a three-wire system. The voltage to ground is equal to 1.41 times the phase voltage. Accordingly, the insulation of the motors and equipment will be subjected to about 310 volts to ground, and there will be a greater liability of motor breakdowns, due to insulation failure on a three-wire system.

Chicago, Ill. A. NOEPPEL.

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Answering J. M.'s question, the only precaution to be observed in connecting the two wires forming the neutral, is to determine by test which pair of wires constitute a phase. When this has been done, either wire of one phase may be connected to either wire of the other phase to form the common lead. Two-phase systems are as a rule operated from generators having two separate and distinct windings. A test made with lamps, or preferably with a voltmeter will, show without question which pair of wires belong to each phase. With the usual system of four wires no reading on low-voltage circuits will be obtained if one wire of each separate phase is picked out. However, with an interconnected system, the voltage between phases will be the voltage per phase multiplied by 1.414; that is, if the voltage per phase is 110 the voltage between phases will be 110×1.414=156 volts. This test is, of course, one that can also be made when the common lead has been made up by testing between the outside wires. The only serious mistake that might be made is to connect together the two wires of the same phase, causing a short-circuit.

C. OTTO VON DANNENBERG.

Designing Engineer,
Sanderson & Porter,
Springdale, Pa.

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Replying to the question by J. M. in reference to changing from four-wire, two-phase to three-wire, two-phase, the first essential is to make sure by voltmeter or lamp tests between phases and from all four wires to ground that he has two non-interconnected phases.

Having found say, that the middle point of each phase is grounded or that the phases are interconnected in the generator, the connection of any two of the four wires would give a short until these interconnections were cleared.

Having determined that he has two independent phases he will find with a lamp or voltmeter that he has full line voltage from No. 1 wire to one of the other three, and the same voltage between the remaining two. Each of the other four possible ways of pairing the wires should give little or no voltage. He should connect together any two of these four potential wires, and use this jumped connection for one of his three wires, the other two wires forming the remainder of the system. Either of the other two connections would give a short-circuit.

There is, of course, every reason for connecting together the inside terminals of his four-pole service switch, interchanging wires to make this posible if need be. The same two wires (or single wire if he runs but three) should run to the inside poles or pole of every branch switch, cutout, and the like, if he expects to continue the use of any two-phase, three-wire motors.

In connecting the motors for three-wire service, the same procedure should be followed, except that, instead of getting a voltage between No. 1 wire and one other, he will find a closed circuit which he can determine with a lamp and power, or by ringing with a magneto so as to get the two pairs. Do not connect together two leads on which a ring is obtained, but join together any pair of leads on which the magneto does not give a ring. The jumpered pair should connect to the middle pole of the switch. To reverse rotation, reverse the outside poles of the switch only, never the middle.

If lights are to be connected, care must be taken to connect them between the middle pole of the switch to an outside pole, for the voltage between the outside legs will be 41 per cent more than the circuit voltage. In fusing and wiring, J. M. will likewise have to consider the fact that the middle leg carries 41 per cent more current than the outside ones. E. D. CARTER.

Engineer,
The Baylis Company,
Bloomfield, N. J.

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Referring to the question asked by J. M. regarding the method of changing a four-wire, two-phase circuit to a three-wire, two-phase circuit, he will have no trouble in making this change and can connect either of the two wires of one phase to either of the two wires of the other phase, to obtain the common wire. This common wire when so connected will carry 1.41 times the current of either phase and should have at least 1.41 times the area of either of the remaining wires.

The voltage between the two outside wires of a three-wire, two-phase system will be 1.41 times the voltage of either phase. For example in a two-phase system, one phase is 90 deg. ahead or behind the other and adding vectorially the effective voltages of both phases we get a resultant voltage of 1.41 times the phase voltage.

In other words, the voltage between phases could be obtained from the maximum point (divided by 1.41 for effective values), on the curve of instantaneous values, derived by adding the algebraic sum of the two sine waves, which represents the current value at any instant in the two phases.

The ordinary motor has two phases entirely separate and there will be no trouble in connecting one wire of either phase to either wire of the other phase. Using four wires, there are four fuses all of the same size. Since the current across the common wire, when using three wires is 1.41 times as large as was formerly carried in each of the four wires, it will be necessary to use a larger fuse in place of the two fuses previously used. If all four fuses are kept in service, care should be taken to see that the fuse contacts are kept in good order, so that the current will divide equally between the two fuses for otherwise one common wire fuse will take more than its share of the load and blow, thereby putting the load on the other common wire fuse.

Seattle, Wash. W. MONTELIUS PRICE.

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The following is my method of solving the problem given in J. M.'s question in regard to changing a two-phase, four wire system to a two-phase, three-wire system. The most complete method of making this change would take into consideration the relative polarity of the two phases, that is, after the change from four-wire to three-wire had been made, the phase rotation in the three-wire system would be the same as that of the four-wire system. By this method it would be necessary to determine the polarity of each phase in both the four-wire and three-systems, so as to make them agree. The method of determining polarity can be ascertained from the very excellent article by L. P. Staubitz in the December, 1924, issue of INDUSTRIAL ENGINEER. This method outlines the method of determining polarity at the transformer terminals. J. M. could also determine the polarity at the watt-hour meters located at the source of power supply.

In case neither of these methods could be applied, J. M. should measure the voltage across different pairs of wires until he finds a pair giving zero voltage. This pair should be connected together and the voltage measured between the two remaining wires. The measured voltage should equal 1.4 times the voltage across either phase. Should he connect two wires of opposite polarity together to form the common wire it would not cause any trouble except that it would change the direction of rotation of the rotating field, and a motor connected thereto would revolve in the opposite direction. This could be readily changed, however, by interchanging leads at the motor.

I would suggest that no fuse be placed in the neutral or common wire. The current in the neutral wire is 1.4 times the current in either of the outside wires. If the neutral fuse should blow, the motor will run single phase and since the resulting voltage is 1.4 times the normal voltage between one outside wire and neutral, considerable damage to the motor might result. Moreover, if the three-wire, two-phase system is used for lighting purposes, a blown fuse in the neutral would result in certain lamps being supplied with over-voltage, and others being supplied with under-voltage, in case of load unbalance on the two phases. Assume that one phase is loaded with five 100-watt, 110-volt lamps while the other phase has only one such lamp. Since the single-phase voltage on each phase is 110 volts, the voltage between the two outside wires will be $1.4 \times 110 = 156$ volts. If under these conditions the neutral fuse should blow, each of the five lamps in one phase will receive only 26 volts, while the one lamp in the other phase will have 130 volts applied to it.

The only other change, aside from those that I have mentioned, is to give the neutral wire sufficient capacity. Inasmuch as the current in the neutral wire is 1.4 times the single-phase current, the neutral wire should have a current carrying capacity that is 1.4 times that of either of the outside wires. P. VAN HERK.

Bressoux, Liege, Belgium.

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Replying to J. M., it is not likely that the wrong pair of wires will be tied together to form the common wire, if a voltmeter is used before attempting the connection. I have successfully made several changes of this nature recently and encountered no difficulties. It should be borne in mind that since the current in the common wire is composed of two equal currents displaced in phase by an angle of 90 deg., the resultant current is equal to 1.41 times the current in either wire. Likewise, the voltage across the two outside wires is equal to 1.41 times the voltage between either wire and the common.

For example, a two-phase, four-wire, 220-volt system, carrying a load of 100 amp. on each phase, after being changed to a three-wire, two-phase system will have 220 volts between either wire and the common, but will have $1.41 \times 220 = 310$ volts between the two outside wires. The current in each outside wire will be 100 amp., but the current in the common wire will be $100 \times 1.41 = 141$ amp. In a two-phase, four-wire system that is not interconnected, the voltage between separate phases is zero. It is only necessary to join together one wire from each phase to form the common wire.

Assuming that it is desired to make the change at the transformer secondaries, the usual method is to connect together the two inside secondaries between which the voltage is zero. In connecting motors precautions should be taken so that the two line wires that have 310 volts across them, are not connected across one phase of the motor. If care is taken to see that the common wire is connected to one wire of each phase of the motor, it is impossible to go wrong on the other two.

This change should not affect anything else in the plant that could not be corrected, so long as the common wire is always treated as one wire of either or both phases and nothing is connected across the two outside wires.

San Francisco, Calif. W. O. HURLBUT.

Electrical Service

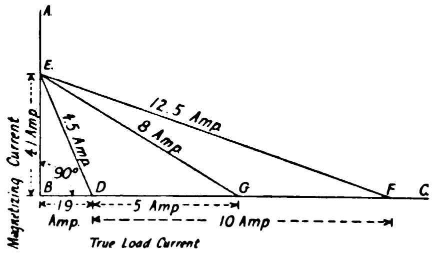
around the works

For this section short articles describing ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing, and emergency or special installations.

Graphic Method for Determining Power Output of Induction Motors

A GRAPHIC method for obtaining a fair idea of the power required to drive certain machines has been found valuable, where no wattmeter was available, or lack of time did not permit its use. This method is not claimed to be as accurate as the wattmeter method, but it certainly is more accurate than taking a current reading and multiplying by, say, 1 for 550 volts and calling the result the horsepower required. Consideration is taken of the motor losses and magnetizing currents even if they are a little high or low.

In finding the necessary data proceed as follows: (1) Note the motor rating with regard to horsepower, r.p.m., frequency, terminal voltage, and full-load current. Determine no-load current, that is, with the belt off or uncoupled, and line voltage. In the case of wound-rotor motors, the magnetizing current may be fairly closely determined simply by raising the brushes from the slip rings and measuring the primary current. (2) Take readings with an ammeter and voltmeter when the motor is driving its normal load. Make note of these readings and the corresponding line voltage. For good results, line voltage should be stable. (3) Approximate the efficiency of the motor to ascertain the losses, and also the power factor at full rated load.



The horsepower load may be determined from the current drawn by an induction motor, by means of a diagram like this, as explained in the text.

For example, take a 50-hp., 2,200-volt, 60-cycle, six-pole motor which was tested by this method and checked against its characteristic curves. Full-load current is 12.5 amp., no-load current is 4.5 amp., approximate efficiency is 85 per cent at full load, and approximate power factor is 94 per cent at full load. The losses are equal to 100—85 =15, per cent, or for this 50-hp. motor the losses would be 7.5 hp. The amperes per horsepower at full load equal 12.5÷50=0.25, and for 7.5 hp. this would be 7.5×0.25=1.9 amp. A full-load power factor of 94 per cent at rated voltage and frequency equals the cosine of 20 deg.

Draw any right angle as shown in the accompanying diagram. Let the horizontal line *BC* represent true power in amperes and the vertical line *AB* represent the reactive component in amperes. Then the hypothenuse will represent the line amperes as read from an ammeter. Now with any convenient scale lay off, from the intersection of the two lines *AB* and *BC* on the horizontal line, 1.9 units, or *BD*, representing the loss in amperes. From *D* draw a line *DE*, 4.5 units long cutting *AB* at *E*. *BE* represents the magnetizing current, *ED* is the no-load line current and *BD* is the motor losses at full load (all of these values are in amperes). From *E* draw a straight line, *EF*, 12.5 units long cutting *BC* at *F*. With a protractor, check angle *BFE* which should be close to 20 deg. Scale *DF* is equal to 10 units and represents 50 hp.; therefore 1 unit equals 5 hp., and we derive this constant, 5, to be used later.

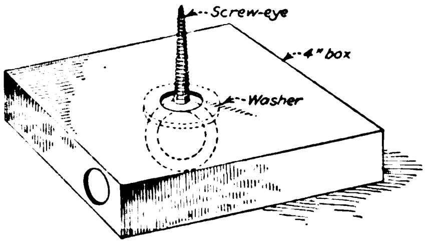
We are now ready to find the horsepower required to drive the load. The ammeter reads 8 amp. and the voltage is 2,200. From *E* draw a straight line *EG* 8 units long, cutting *BC* at *G*. Since *BD* represents motor losses and *BG* represents the total input, the input minus the losses equals the output or *DG* which equals five units. Multiplying these five units by the constant 5, which was found previously, gives 25 hp., or the output required to drive the lead. If the angle *BGE* is measured with a protractor, it will be found to be 31 deg., which corresponds to cos. 0.857 or the power factor of the motor when delivering 25 hp. For a table of efficiencies and other characteristics of induction motors, consult any good handbook. W. L. STEVENS.
New Westminster, B. C., Canada.

Method of Suspending Heavy Fixtures from Wooden Beam

RECENTLY the problem arose of suspending four heavy fixtures from a wooden beam in an inexpensive manner. There was already in place a conduit run having 4-in. square boxes fastened to the bottom of this beam where each fixture was to be located, and which was used for other purposes. This made it necessary to use these boxes or rearrange the conduit.

Accordingly a hole was drilled through each of the four conduit boxes for screw-eyes which were screwed into the wooden beams. The fixture proper was supported by three chains which were attached to a hook with a ½-in. stem, suspended from the screw eye.

The conduit box was covered by a canopy and which enclosed all of the wiring splices, as well as the screw-eye. Naturally, a job of this sort entailed the precaution of securing a good ground, which was accomplished by imbedding the screw-eye deeply in the



Simple suspension for heavy fixtures in a conduit installation.
The screw-eye is fastened to an overhead beam through a hole drilled in the conduit box, and grounded against the washer.

beam so that it pressed firmly against the washer and conduit box. This job was approved by the Underwriters.

We used a screw-eye of sufficient size and strength to hold the fixture. The sketch shows how this simple suspension was made. By its use we saved ourselves the inconvenience and extra cost of changing the conduit installation. NATHAN W. BLANCHARD.
Inwood, Long Island, N. Y.

Interlocking Control System for Overhead Tramways

THE following scheme was proposed for transporting crushed rock from a quarry to a cement mill located approximately 5½ miles distant, by using three overhead tramway systems with buckets suspended for carrying the crushed rock. The material is carried uphill out of the quarry by tramway No. 1, shown in the diagram, and then down grade to where it connects with tramway No. 2. Tramway No. 2 takes the material and conveys it to No. 3, which delivers it to the cement mill.

Buckets are suspended at equal intervals from the overhead cables of each of the three tramways, so that when a full bucket from No. 1 arrives at the dumping place, an empty bucket from No. 2 is ready to receive it. Similarly No. 2 tramway disposes of

its load to No. 3. As a matter of fact, a small amount of storage space is available between the tramways, but only enough to take care of one bucket load. It was, therefore, essential that the speeds of the three tramways be kept the same, although it was not desired to use a complicated control.

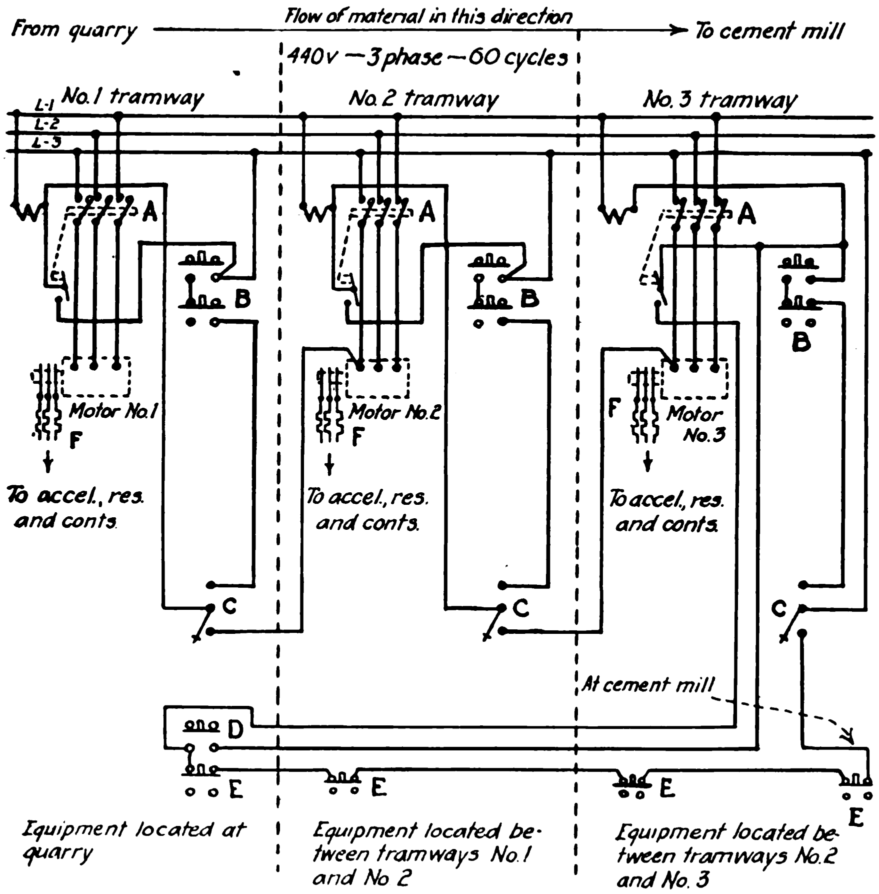
To accomplish the desired results, it was proposed to drive each of the three tramways by a 100-hp., 900-r.p.m., 440-volt, three-phase, 60-cycle, slip-ring motor equipped with a solenoid brake. When the tramways are at rest something in excess of full-load torque is required to start them moving, but when all the descending buckets are full, the motors of No. 2 and No. 3 tramways are overhauled and act as induction generators, developing approximately 80 hp. and 90 hp. respectively, and pumping current back into the line.

Tramway No. 1 differs from the other two in that the full buckets descending the 6 per cent grade are more than counterbalanced by the full buckets coming up the 16 per cent grade and it is necessary for the motor to supply the extra power necessary to operate this tramway. As this motor is always pulling a load it can never run as fast as 900 r.p.m.; its speed will always be less than this value. On the other hand, the other two motors, being overhauled, will always run above 900 r.p.m.

It is a well-known fact that the speed of a slip-ring induction motor can be changed within certain limits, by varying the amount of secondary resistance. It is probably not so generally known that inserting secondary resistance tends to increase the speed of the machine when it is acting as an induction generator, although it will decrease the speed when operating as an induction motor.

If all three tramways were geared to their respective motors with the same gear reduction it would never be possible to fulfill the requirement of operating them all at the same speed. No. 1 tramway would always operate slower than No. 2 and No. 3. It was necessary, therefore, to gear up the speed of No. 1 tramway slightly above the regenerative speeds of No. 2 and No. 3 and get speed adjustment by inserting resistance in the secondary of No. 1 motor. Besides the permanent resistors for final speed adjustments, the control equipment included three standard, General Electric, Type CR-7012-B1 starters and accelerating resistors with standard push button stations.

Important requirements of operation were: (1) Under usual conditions of operation all three tramways must operate at the same time when conveying material. (2) Stopping of any tramway must always cause No. 1 tramway to stop; otherwise there would be a piling up of material at the stalled tramway. (3) In case of an emergency it must be possible to stop the entire system from any one of four locations; that is, at each motor installation and at the cement mill. (4) If desired, any tramway must be capable of being operated independently of the others for the purpose of testing out motor and control equipment.



Control apparatus used to operate overhead tramway system for transporting crushed rock from a quarry 5½ miles distant from the cement mill.

A, line contactors for motors Nos. 1, 2 and 3. *B*, "Start-Stop" push button stations for individual operation of the motor starters. *C*, selective snap switches to operate motors in sequence or individually; "down" for sequence operation and "up" for individual operation. *D*, start button used for sequence operation when selective switches *C* are in the "down" position. *E*, emergency stop buttons. *F*, permanent resistance to adjust speed.

As indicated in the diagram, tramway No. 3 is started by the proper push button station located at the quarry. As soon as the line contactor of No. 3 motor closes, No. 2 motor starts up. Similarly, No. 1 motor starts when No. 2 motor contactor closes. Therefore, No. 1 motor will always shut down no matter which motor stops, which will prevent piling up of material between any two conveyors. In case it is desired to operate any starter without its being in sequence with the other two, this can be accomplished by pushing the proper double-throw snap switch *C* to the "up" position.

The above system of overhead conveying makes it possible to carry material over forest land, swamps, ridges, ravines, and so on. Also, since the material is mainly carried down grade, it is possible to obtain braking by the regenerative action of the motors, the economy of which is two-fold: (1) The regenerative current from the motors is used to run motors in the cement mill and quarry, thus reducing the load on the power plant. (2) Regenerative action is superior to mechanical braking as there is an entire absence of mechanical friction and consequently there are no brake shoes to replace or periodically adjust. The solenoid brakes referred to previously are used only as holding brakes when the tramways are at rest, or for deceleration in emergencies when the motors are shut down because of overload or voltage failure.

R. F. EMERSON.
Industrial Engineering Dept.,
General Electric Co.,
Schenectady, N. Y.

Difference Between 40-Deg. and 50-Deg. D. C. Motors and Their Ratings

UNTIL a few years ago, all direct-current motors were known as 40-deg. designs. The difference between 40-deg. and 50-deg. motors is in the temperature rise in the windings when operating at full load. Under these conditions 40-deg. motors have a maximum allowable rise of 40 deg. C (72 deg. F) above room temperature. When operating continuously at full load, they are good for a 25 per cent overload for a period of 2 hr. with a 55-deg. rise in temperature. A 50-deg. motor has an allowable rise in temperature of 50 deg. C when operating continuously at full load and has no allowance for any overload whatsoever. This means that on the basis of 72 deg. F. a 40-deg. motor will rise to a temperature of 144 deg. F and a 50-deg. motor will rise to a temperature of 162 deg. F. The maximum temper-

ature is, of course, on the inside of the winding and is usually about 15 deg. hotter than the observed temperature indicated by a thermometer on the outside of the winding. The difference between this maximum temperature and the temperature of the air around the motor gives the rise.

Naturally, a 40-deg. motor will be larger than a 50-deg. motor of the same rating. The 40-deg. motor contains more laminated iron in its core and more copper in its coils because its temperature rise must be less on the same load. There is practically no difference between a 10-hp., 50-deg. motor and a 7½-hp., 40-deg. motor. The advantage in using a 50-deg. motor is nothing more or less than its first cost, whereas the 40-deg. motor will carry heavier loads and stand more abuse. It has been proven that some motors are built with too much iron for the amount of copper used. In this case the coils will rise to a temperature much higher than the iron and in the event that there is not enough iron, the iron will heat to a higher temperature than the copper.

It is very important to remember that the temperature rise of a motor is given in degrees Centigrade. The latest standardization rules of the American Institute of Electrical Engineers provide that in motors with the class of insulation used in reliable makes of motors, the temperature as recorded by a thermometer should be within a limit of 80 deg. C. This is equivalent to 176 deg. F. No one would dare place his hand in contact with the frame at a temperature anywhere near that limit.

Temperatures of motors are affected by weather conditions. Say, for instance, that a motor has a temperature of 40 deg. F. when operating continuously. Such a motor operating on a day when the normal air temperature is 70 deg. F. would reach a temperature of 110 deg. F. which would be only comfortably warm to the hand. The same motor under the same conditions on a mid-summer day when the thermometer runs from 90 deg. to 95 deg. F. will attain a temperature of 130 deg. F. to 140 deg. F. Any temperature over 120 deg. F. is uncomfortable to the hand and usually gives rise to alarm on the part of some motor users. However, a motor with a surface temperature of 140 deg. F. is in no danger of overheating. Unless there is an odor of burning insulation the motor cannot be considered in danger. According to standards of the A. I. E. E. the life of the machine insulation depends upon the actual temperature attained by the different parts, rather than on the rise of temperature in those parts. These temperatures can be obtained by using one of the standard methods.

It is a well-known and proven fact that the rating of motors is determined by the continuity of operation, which must accordingly be considered in making a selection. The heating of the machine, due to passing of electric current through it, largely determines the rating.

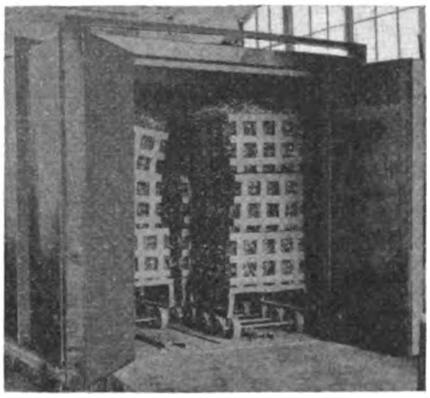
A motor can be rated higher for intermittent service than for continuous service; conversely, a motor rated for intermittent service must not be used at the same rating for continuous service. In any service a motor can nearly always deliver more than its standard continuous rated output for short periods only, with intervening periods of rest. This fact is often overlooked and motors larger than necessary are accordingly selected.

J. K. WITHERSPOON.

Electrical Engineer,
Railway Steel Spring Co.,
Latrobe, Pa.

Electrically Heated Oven Used for Tempering Springs

AN ELECTRIC oven is being used by the Royal Blue Spring Co., of Cincinnati, Ohio, very successfully in the tempering of bed springs. Tempering is a very important process in the manufacture of these springs; for good results temperature control must be close and heat distribution uniform.



This electrically-heated oven can handle a charge of 1,800 lb. of bed springs, which are packed in steel baskets for tempering.

The spiral springs are rolled into shape by machines which were especially designed for this purpose, and packed in steel baskets. These baskets are loaded on trucks and placed in the electric oven to be tempered, as shown in the illustration.

This oven, which was built in the plant of the Royal Blue Spring Co., is 10 ft. long by 6 ft. wide by 6 ft. high. Type C, Westinghouse heaters, of a total capacity of 60 kw. are arranged along the oven sides. One of the features of this oven is that it can be loaded to capacity without injuring the quality of the work. This was not the case when other methods of heating the oven were employed, as the oven temperature was not always uniform. The maximum load of this oven is about 1,800 lb. of spiral springs.

Losses from radiation are prevented by 4 in. of insulation on all sides of the oven. When operating at 275 deg. F. the oven exterior is cold and at 475 deg. F. it is only moderately warm on the outer surface. The amount of heat radiated is so small that it does not inconvenience the workmen in any way.

Starting the oven when cold and at full load, the operating temperature of 475 deg. F. is reached in about 2 hr.; when empty this time is cut down to approximately 1¼ hr.

Regulating Equipment Prevents Load From Exceeding Maximum Demand

A NEW and interesting installation of load regulating and transfer equipment was recently made by Rockwood & Company, cocoa and chocolate manufacturers in Brooklyn, N. Y. This company purchases most of its power in the form of alternating current from the Brooklyn Edison Company on a maximum demand basis, and the object of installing the new equipment is to maintain the load on the power lines as near to the agreed maximum demand as possible.

A large proportion of the plant load is alternating current, but there is also a large number of direct-current motors and other apparatus. Power for the a.c. load is supplied directly from the incoming power lines through transformers, but power for the d.c. load is supplied by two generators, operated in parallel, on the premises. One, a 200-kw. generator, is driven by a Corliss engine which also drives a mechanical load, and the other, a 300-kw. machine, is driven by an alternating-current motor.

As the a.c. load shifts rapidly, it was previously quite difficult to hold the maximum demand within the necessary limits. With the present regulating equipment, the proper load demand on the incoming a.c. lines is maintained by automatically transferring the excess load to the 200-kw. engine-driven generator or *vice versa.*

When the two d.c. machines are first started and the load begins to come on, the current divides between them in proportion to their respective capacities. As soon as the load on the 200-kw., engine-driven generator reaches approximately 25 kw. any load above that point is diverted to the 300-kw. motor-generator set until the maximum alternating-current demand has been reached.

With this generator fully loaded, any additional load is diverted back to the 200-kw. machine until both are operating at maximum load, when a gong rings, indicating that part of the load must be taken off. If the maximum a.c. demand point is reached before the 300-kw. generator is fully loaded, the excess d.c. load will be automatically transferred to the 200-kw. engine-driven generator.

The engine which drives the 200-kw. generator is running at all times, driving its mechanical load, its generator either running light or carrying that portion of the d.c. load necessary to maintain the load balance.

The load regulating equipment was designed and built by the General Electric Company in co-operation with the engineers of the Brooklyn Edison Company and the Rockwood & Company. It consists of a contact-making wattmeter, which is directly responsible for the master control of the system, and various relays and contactors for shifting the load, protecting the equipment, ringing the gong, and the like. Push buttons and switches provide for hand control of the system when necessity demands its use.

Mechanical maintenance of

Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through the auxiliary transmitting equipment to all driven machines.

Comment on Operating Speed of Roller Chains

ON PAGE 87 in the "Question and Answer Department" of the February, 1926, issue of INDUSTRIAL ENGINEER, A. B. Wray, Morse Chain Co., Ithaca, N. Y., expresses his opinion that 1,800 r.p.m. is too great a speed for the use of a roller chain.

Without desiring to enter into any controversy concerning the respective merits of the silent and roller types of chain, each of which has its field of application, it is unquestionably true that these fields overlap, and that the transmission of power at speeds of 1,800 r.p.m. is within the capacity of both types.

Our roller chains are recognized as being suitable for speeds, not only of 1,800 r.p.m. but considerably higher, as both single and multiple strand chains, have been used in such service for years, and new applications are being made regularly.

W. A. WARRICK.

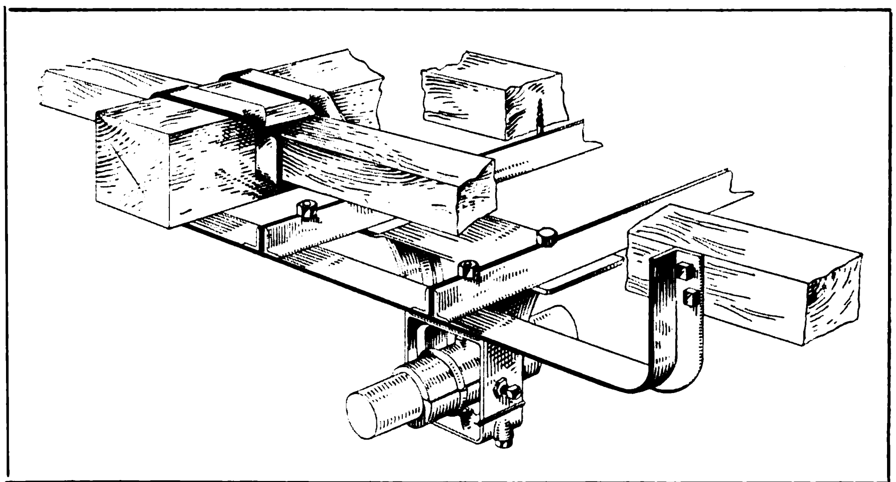
Mechanical Engineer,
Diamond Chain & Mfg. Co.,
Indianapolis, Ind.

Supporting Lineshafts in Mill-Type Building on Standard Angle-Iron Groundwork

WHERE the buildings of an industrial plant are of a uniform type many economies result from the establishment of a standard form of construction and installation of lineshafts. Two of the main advantages are that the men know exactly how the work is to be done and so can go ahead with less supervision; also when it is necessary to make a change in the location of a shaft practically all the material is re-usable without additional fabrication.

The standardized groundwork used by the Master Mechanic in one large industrial plant is shown in the accompanying sketch. As may be seen from the drawing, this consists practically altogether of standard angle irons which are laid in pairs to take the feet of the hangers. These footings are supported on other angles which are bent so that they may be fastened to the beam construction by lagscrews. To give the rails or footings additional support a few long lagscrews extend from between the rails to the ceiling beams, as shown. These extra lagscrews are placed near a hanger and on the opposite side from the angle-iron cross-piece supporting the rails.

This Master Mechanic, also, has the feet of the hangers planed to give them a more firm and true footing against the angle-iron rails.



This form of standardized construction of groundwork for supporting lineshafting in mill-type buildings is used in one large industrial plant.

Operating Economies Which Resulted from Installing Ball-Bearing Lineshafts

IN 1913 our manufacturing load had become so great that our power plant was inadequate to handle it. Something had to be done and we decided to cut down the amount of power that was being wasted in overcoming lineshaft bearing friction. Ball-bearing hangers and pillow blocks were first installed on the lines where the friction load was considered to be greatest; namely, shafts carrying heavy loads with the belts all pulling in one direction. Other shafts were equipped later. These hangers were of the SKF type, which are now used almost exclusively in our plant.

The shafts driving the punch presses, grinders, emery wheels, and grindstones also run in SKF hangers and pillow blocks. Similar bearings are used in the fans and blowers and in the emery wheel stands. The sizes of the shafts vary from 4 in. down to 1$\frac{7}{16}$ in. in diameter and the operating speeds vary from 12,000 r.p.m. for the emery wheels to 200 r.p.m. for the lineshafts.

A large saving in power has been attributed to the decrease in friction losses which have been obtained through the use of these bearings. One section of the plant which is supplied by our direct-current generator required between 1,600 and 1,800 amp. at 130 volts before the new bearings were installed. With the same load the current is now 1,200 to 1,300 amp. This has given a minimum reduction of 400 amp. or 25 per cent of the original load. The average power saved per day is 468 kw.-hr., which in a year's time, at \$0.02 per kw.-hr., is worth \$2,808. As this section of the plant takes about one-third of the total amount of power used, the saving from the use of ball bearings in the entire plant would be approximately \$8,424 per year. The power economy alone at this rate would pay for the complete installation in less than two years.

The old plain bearings often burned out in the grinding room and other places where the service was especially severe, but the new bearings have given us practically no trouble and have stood up excellently on the hardest jobs. Our polishing machines provide a good test of a bearing. The old bearings lasted about three or four months, but the new bearings installed in these machines have been in use for several years. Formerly the bearings of one of our fans had to be rebabbitted at least every six months. The new bearings have operated three years and have not caused any trouble, even though the fan operates in a dirty location.

The oiler greases each bearing every 90 days although once in six months would probably be sufficient. Once a year the bearings are cleaned and repacked with grease. The old plain bearings were oiled every day. The cost of lubricating oil used was considerably more than the present cost of the grease.

W. A. ATKINS.

General Superintendent,
A. C. Atkins & Co.,
Indianapolis, Ind.

Using Chart to Determine Horsepower Loss from Friction in a Bearing

THE principal function of the accompanying chart is to speed up computations on bearings and their friction losses. The ease with which these computations can be made with this chart should increase the use of actual figures in bearing design and operation, instead of the rough estimates or guesses, that are frequently employed.

To use this chart, it is necessary to lay a straight-edge across it three times, as indicated by the dotted lines. It will give the horsepower consumed by any bearing with co-efficients of friction varying from 0.0006 to 0.6, with shaft diameters from 0.1 to 10 in., at speeds from 100 to 10,000 r.p.m., and with a load on the bearing varying from 10 to 10,000 lb.

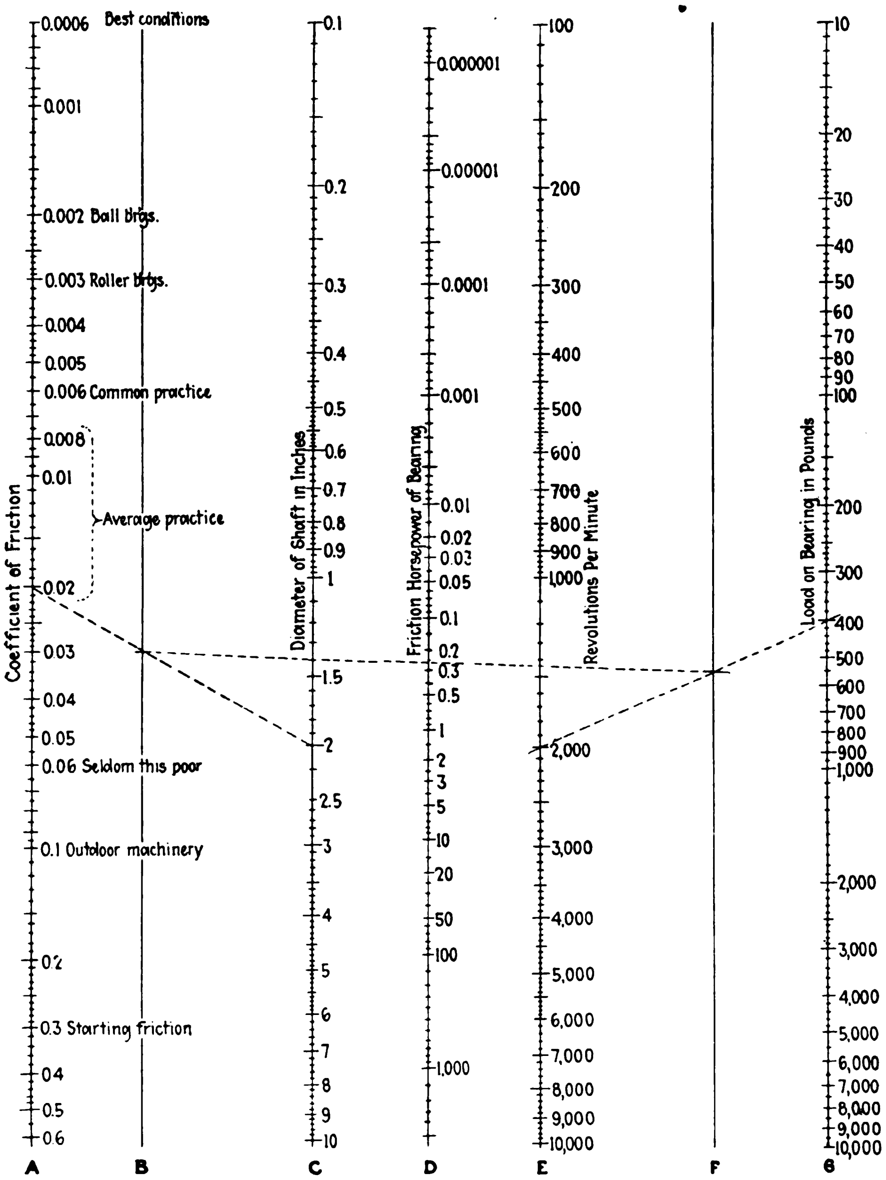
For example, assume that in a particular bearing the co-efficient of friction is 0.02 (column *A*) which is average practice for plain bearings, the shaft diameter is 2 in. (column *C*), the speed is 2,000 r.p.m. (column *E*), and a 400-lb. load is carried by the bearing (column *G*). Column *D* gives the friction loss as a little over 0.25 hp. To get this result connect with a straight-edge the known value in column *A* with that in column *C* and locate the intersection with column *B*. In the same way connect columns *E* and *G* and locate the intersection with column *F*. Then connect the intersections (columns *B* and *F*), and the intersection with column *D* will give the friction horsepower loss of the bearing.

The notations alongside column *A* indicate the co-efficients of friction met with in everyday practice, beginning with the very best conditions of plain bearings and ending with starting friction. Co-efficients of friction under the many possible conditions may be obtained from text-books, such as Alford's "Bearings" and in such handbooks as "Kent" and Mark's new "Mechanical Engineer's Handbook." Only the safe values of approved practice are designated on the chart. As will be noted, a co-efficient of 0.002 is used for ball bearings and 0.003 for roller bearings. All the other co-efficients (column *A*) relate only to the plain bearings.

The chart can, of course, be used backward as well as forward. For example, if the power absorbed by a given bearing is known and the values in columns *C*, *E* and *G* are known, the co-efficient of friction may quickly be determined. Then, knowing the co-efficient of friction with a given oil and in a given bearing, the power required by a similar bearing of different diameter, speed and loading may be found with an accuracy sufficient for most practice.

W. F. SCHAPHORST.
Mechanical Engineer,
Newark, N. J.

With the factors which affect friction, known or estimated from practice, the horsepower loss in any bearing can be easily determined by using this chart.



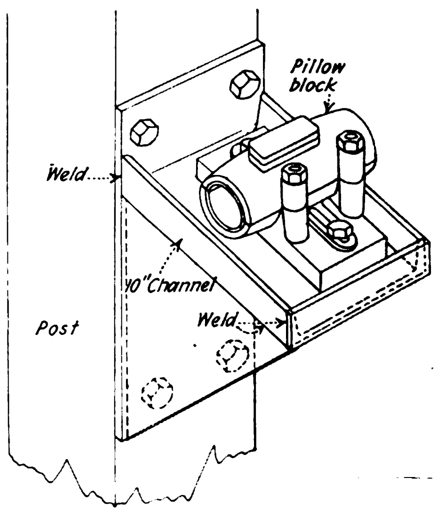
Method of Welding Up Steel Post Bracket for Pillow Block

WHEN it is necessary to support lineshafting from wood or steel columns and cast-iron brackets are not available, a very solid and effective bracket can be made out of a piece of heavy channel iron and several pieces of steel plate. A method of doing this is shown in the accompanying sketch.

The piece of channel must be wide enough to carry the size of pillow block on the inside or web of the channel and at least 2 or 3 in. longer than the block.

The bracket is made by welding two triangular pieces of ⅜-in. steel plate to the bottom of the channel and also to a piece of ⅜-in. plate of rectangular shape which is attached by bolts or lagscrews to the column, as is shown in the accompanying sketch. The front of the channel has a piece of lighter gage plate welded across it, which forms, with the sides of the channel and the back plate, a reservoir to retain any oil which leaks out of the bearing. Holes are cut in the web of the channel, so that the pillow block may be bolted down. Surplus oil is removed through a drain which consists of a short nipple with a pipe cap. The nipple can be welded on or a hole bored through the web and tapped.

Hollywood. Calif. M. C. COCKSHOTT.



These post brackets for pillow blocks were made up from a piece of channel and three steel plates welded together.

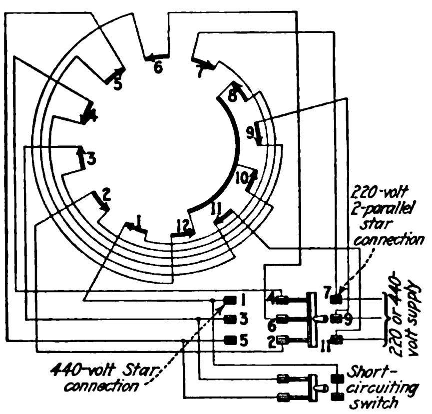
In the Repair Shop

This section is devoted to repair work on electrical and mechanical equipment. Special attention is given to shop or bench tools and short cuts or improved methods of handling work of this character. Contribution are always welcome.

How to Connect Motor for Use on 220 or 440 Volts

IN PLANTS where 220 and 440 volts are used, spare motors might have to be cut over in a hurry from one voltage to the other and a great deal of time lost by reconnecting. There is also the possibility of rented motors or portable sets having to be reconnected to suit the voltage.

The winding of a three-phase, four-pole motor can be arranged for quickly changing the connection from single star to two-parallel star or *vice versa*, by bringing out nine leads and connecting them to a three-pole, double-throw, knife-switch, as shown in the diagram.



For a four-pole motor, nine leads are brought out from the stator winding and connected as shown.

By throwing the three-pole reversing switch to the left a 440-volt, single-star connection is obtained. When leads *1*, *3* and *5* are short-circuited and the reversing switch is thrown to the right, a 220-volt, two-parallel star connection is made.

By throwing the switch to the left, a single-star connection is formed, for use on 440 volts. With the switch thrown to the right, the winding is connected two-parallel-star for 220 volts. When the switch is in this position, terminals *1*, *3* and *5* must be shorted by a double-pole, single-throw switch to form the other star point.

This method can be applied to either a four- or six-pole winding. When connected for six poles, the groups must be laid out and numbered in the same way as for four poles, only there will be 18 groups instead of 12, as in a four-pole connection. Consequently there will be more jumpers, but there will be 12 leads from 12 consecutive groups; the first six will be starting leads and the last six will be finishing leads. It makes no difference which leads you count as the same connection is obtained. Out of 12 leads, Nos. *8*, *10* and *12* form the star, and should be connected inside of the motor. This is done also in the four-pole connection in the diagram.

Los Angeles, Calif. HENRY KAELIN.

Comment on "One Man Should Be Responsible for Plant Operation"

I READ with much interest, "One Man Should Be Responsible for Plant Operation," on the editorial page of the November, 1925, issue of INDUSTRIAL ENGINEER. In my opinion, based on experience in the electrical and mechanical departments, the direct result of having one head for the two departments will accomplish one very essential condition necessary for successful maintenance: that is, "team work."

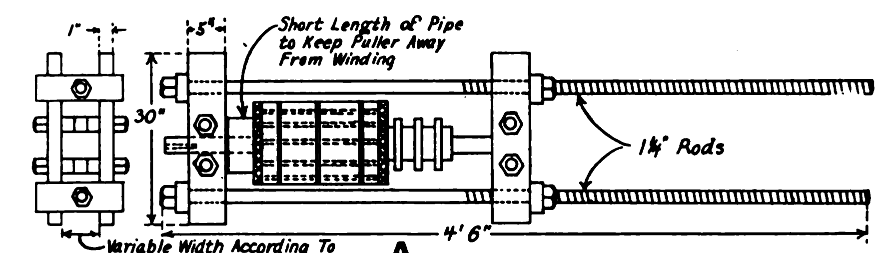
As a preliminary step, I believe the men selected as foremen of the mechanical and electrical departments should be both willing and capable of being trained in each of these branches. This will result in better and faster work as each one will know what the other fellow is up against. Then again, it puts these men in a competitive position to fill the maintenance engineer's job should that become vacant. I might add that the Master Mechanic or Maintenance Engineer is usually a mechanical-electrical man having charge of both departments.

The following repair job which came in a few days ago will illustrate the result of team work at this plant. One morning recently a steamer with 4,000 tons of coal came in to be unloaded, and shortly before she docked the shaft of the 40-hp. induction motor operating the conveyor belt broke at the inside end of the bearing, allowing the rotor to drop and damage several rotor cells. This happened about 9:30 a. m.; at 11 a. m. the motor came into the shop and an emergency requisition was made out for shaft stock, which arrived at noon. Meanwhile the rotor was taken out and upon test was found to be grounded. As no press was available the puller, shown in *A* of the accompanying diagram, was rigged up. Both core and rings were very tight on the shaft and required two men with 3-ft. extensions on the wrenches to draw them off. Roughing out the shaft commenced at 12:30 p. m. By 3 o'clock the rings were off, and the core was removed at 6:30 p. m. Meanwhile the bearings had been poured and were being bored out.

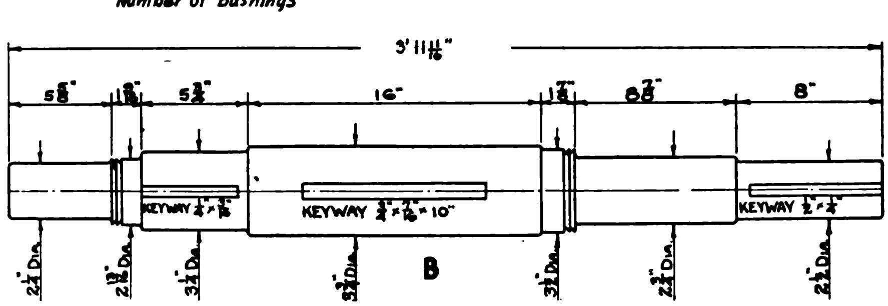
The electric shop had the core at 6:45 p. m. and upon testing it found that the trouble was confined to one phase. As there were four coils per phase per pole, we disconnected the four coils at one spot on the back end and after testing again, disconnected two more further on. More tests showed the trouble to be between the

Teamwork and ingenuity were the deciding factors in speeding up this emergency motor repair.

A is a puller that was rigged up to remove the rotor shaft. *B* shows the amount of work which was necessary on the rotor shaft that was turned out in about 15 hr.



A



B

disconnected places and after removing the connectors of these coils at the front end, the trouble showed up in two slots only. The bands were removed and enough connectors were taken off to remove the defective coils. New coils which we had on hand from a previous job were inserted and tested out with a Megger.

A little rivalry developed between the two departments as to which one would be ready first. The machine shop won by 1¼ hr., having finished turning the shaft at 2 a.m. and cutting the three keyways at 4:00 a. m. the following morning. The electric shop finished at 5:30 a. m., except for the connections to the star ring and banding, which had to be done after assembling. Diagram *B* shows the amount of work done on the shaft, the material of which was 3⅞ in. in diameter. Assembling was finished at 8:30 a. m. and the same rigging which was used to pull the core off the shaft aided again in the work. At 8:45 a. m. the star ring was being soldered and the connectors straightened up, after which a thorough examination for solder bits between coil ends was made. The core was banded and completed at 11:15 a. m. and at 12:30 p. m. the motor was completely assembled and left the shop. The motor had to be transported about ⅛ mile and hoisted up 45 ft. to its position on the bridge. It was in operation at 3:00 p. m. of the same day, being out of service just 29½ hr. If a press had been available for removing the rotor shaft, considerable labor would have been saved and the total time out of service reduced 1¼ hr., as the electrical department could not commence work until 6:45 p. m. of the previous afternoon.

CHESTER A. WILLIAMS.
Electrical Dept.,
Providence Gas Co.,
Providence, R. I.

Making the Slide Rule Add and Subtract Percentages

ANY ordinary slide rule can in a few minutes be adapted to add and subtract certain fixed percentages, by the simple method described here. The adding and subtracting feature consists of a small arrowhead placed on the underside of the glass slider and permits the addition or subtraction of percentages up to about 25 per cent on the *A* and *B* scales, and about half that amount on the *C* and *D* scales. Placing the arrowhead as shown in the accompanying illustration does not interfere with the operation of the slide rule when using it for other work. It is essential, however, that it be made and located carefully or it will be of doubtful value.

For example, in reading the *C* and *D* scales as noted on the slide rule illustrated, the arrow to the left of the hairline points to 2.85 on the *D* scale, or 95 per cent of (1.5×2), which is a subtraction of 5 per cent. To locate the arrow for this per cent subtraction, place the hairline on 1.05 on the *D* scale and the arrow at 1, which then really represents 95 per cent. The arrow at the right of the hairline indicates 3.15 or addition and would be located by placing the hairline on 1 and placing the arrow at 1.05 on the *D* scale. By simply moving the slider glass to any value desired on the *D* scale, the fixed ratio of 5 per cent addition or subtraction may be read. The same procedure is used for locating the arrow for any other percentage or when using scales *A* and *B*.

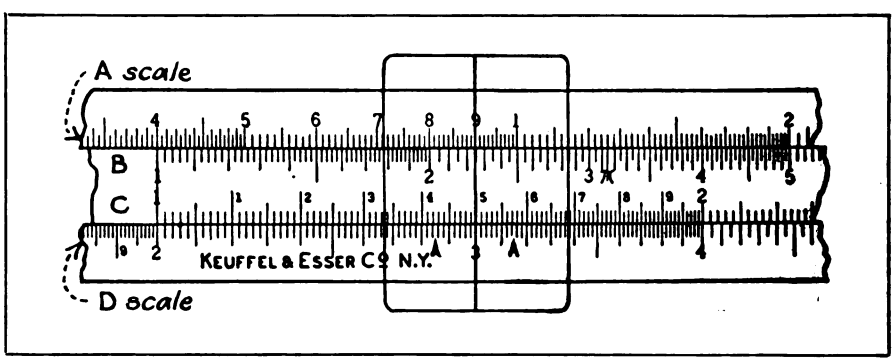
For example, to locate the arrow for 15 per cent addition on the *A* scale, the hairline would be placed on 1 and the arrow located at 1.15.

An arrow cut from a piece of black carbon paper will answer the purpose very satisfactorily. Supposing it was desired to add 10 per cent on the *C* and *D* scales. The arrow should first be moistened on the back or plain side of the carbon paper and stuck on the *D* scale, being adjusted with a pin at 1.1, so that the point just touches the smallest graduations. The glass, from which the bottom or spring runner has first been removed, should be touched with library paste at the place where the arrow will come. Next, the glass should be moved, with the top runner firmly pressed against the rule, to a position where the hairline will coincide exactly with 1, and then gently pressed down upon the arrow, which will adhere to the bottom side of the glass. It should be left to set for perhaps a minute, and then removed and allowed to dry. When dry, the superfluous paste should be carefully trimmed from around the arrow, and a small drop of white shellac applied over and around the edges of the latter. When the shellac hardens it may be carefully trimmed with a sharp knife, so as to leave a protecting coat around the edge of the carbon paper. By making the arrow in this way it will be found to last indefinitely and will stand any rubbing necessary to clean the glass. At the same time, it can be quickly removed when one desires to change the percentage reading.

A slide rule altered in this manner is very useful, for instance in estimating, where a certain fixed percentage of profit must always be added to figures obtained, or in adding overhead to cost figures. In the case of slide rules which have a sufficiently wide glass, an arrow may be placed to eliminate one operation in reading the area scale. A 15 per cent arrow will also serve to show, for instance, the width across points of hexagon stock where the width across flats is given. It will be easy to find a good many applications for this scheme, including some where a given percentage also has two or more useful meanings.

Santa Ana, Cal. HENRY SIMON.

By placing small arrows at the proper points on the slide rule glass, a fixed percentage may be added or subtracted at each reading.



Changing the Frequency of an Induction Motor

OFTENTIMES it is very desirable to change a 25-cycle motor to a frequency of 60 cycles. The latter frequency is found more desirable for ordinary purposes when overload is not encountered to any great extent. The question of how to make such a change is frequently raised, and this article will show the procedure in a particular case.

In order to change a 25-cycle, 440-volt, 750-r.p.m. squirrel cage induction motor over to 60 cycles at the same speed and voltage, it is necessary to rewind the motor. The reason for this is, that a 25-cycle motor operating at 750 r.p.m. has four poles, while a 60-cycle motor requires ten poles to give the same speed. If the coil pitch of the four-pole, 25-cycle winding is between 50 and 70 per cent and the winding is reconnected for eight consequent poles, that is, four north-pole groups, the motor will operate under the same conditions as would a 538-volt motor on a 440-volt line, or 20 per cent undervoltage. A number of coils equal to 10 per cent of the total should be cut out, which would reduce the full-load rating at least 15 per cent.

In following the above procedure, the resistance of both the end rings on the motor will have to be increased to help provide sufficient torque without pulling excessive current at starting. The end resistance may be increased as follows: where the construction and type of the rotor permit place it in a lathe and turn it down. This is a cut-and-try procedure, as anywhere from 20 to 50 per cent reduction in ring area may be required. A second method is to put saw cuts in the rings between each bar of both end rings.

For slip-ring motors or wound-rotor types, the rotor winding must be changed whenever a change is made in the number of poles in the stator winding. Additional information on changing the frequency of induction motors can be found on page 187 of the April, 1924, issue of INDUSTRIAL ENGINEER.

Wilkinsburg, Pa. A. C. ROE.

Practical Books

for your personal library

Every man who aspires to larger responsibilities should build up a professional library containing carefully selected volumes on subjects related to his work. Copies of the books which are reviewed here may be obtained from the publishers mentioned.

Electrical Engineering—By Clarence V. Christie, Consulting Engineer and Associate Professor of Electrical Engineering, McGill University, Montreal, Can. Published by McGraw-Hill Book Co., Inc., 370 Seventh Ave., New York, N. Y., third edition, 605 pages, illustrated. Price $5.

In the preparation of this third edition considerable new material was added to bring the volume up to date in addition to making a thorough revision of the second edition. This book was written for use as a textbook and considerable attention is given to the theory of the problems involved. Many of the fundamentals of design of various types of electrical equipment are discussed.

* * * *

Elements of Alternating Current and Alternating-Current Apparatus—By J. L. Beaver, Assistant Professor of Electrical Engineering, Lehigh University. Published by Longmans, Green & Co., 55 Fifth Ave., New York City, 363 pages, illustrated. Price $4.

This book has been prepared for beginners, either electrical or non-electrical students, in the study of alternating currents. The first eight chapters deal with the principles of alternating current in a very elementary way. The vector method of treatment is used as much as possible throughout the text. The last five chapters are devoted to the study of the more common types of alternating-current apparatus, beginning with the transformer. Special questions, which bring out the important details of the text, and problems (mostly with answers) are a part of each chapter.

* * * *

Industrial Electricity, Part II—By Chester L. Dawes, Assistant Professor of Electrical Engineering, The Harvard Engineering School, published by McGraw-Hill Book Co., Inc., 370 Seventh Ave., New York, N. Y., 472 pages, illustrated. Price $2.75.

This volume discusses alternating-current circuits and equipment and is thus a continuation of Part I, which was devoted almost entirely to direct-current circuits and direct-current machinery. The first chapters of this volume are devoted to the fundamental principles and the simple laws governing alternating currents and alternating-current circuits. However, only the simplest mathematics are used. Considerable emphasis is placed on the effect of inductance, capacitance, and frequency in the flow of alternating current.

A chapter is devoted to the construction and uses of the ordinary alternating-current instruments. The relations existing between current and voltage in polyphase systems are pointed out. Likewise the construction and operating characteristics of alternators, polyphase induction motors, single-phase motors, synchronous motors, and converters are explained and briefly analyzed. The relations between the characteristics of these types of power machinery and their industrial applications are also discussed to a considerable extent. The last three chapters are devoted to general industrial applications of electricity, including the methods and general rules which should be followed in the installation of wiring.

* * * *

Processes of Flour Manufacture—By P. A. Amos. Third Edition, published by Longmans, Green & Co., 55 Fifth Ave., New York, N. Y., 299 pages, illustrated. Price $3.

This volume is one of the technical handicraft series. The author in the additions to and revision of previous editions has endeavored to include all the latest and most important developments of the flour milling industry, both in machinery and manufacture. In addition to a thorough discussion of wheat and flour, together with the methods of cleaning, handling and milling, several pages are devoted to such subjects as: power and power transmission, fire risks and safeguards, mill lighting, capacities and speeds of machines, and other general data. An interesting feature of this booklet is that practically all the operations and machinery are shown by diagrams and cross-sections of the equipment.

* * * *

The Induction Motor—By Herbert Vickers, Professor of Electrical Engineering and Head of Department of Mechanical Engineering, University of British Columbia. Published by Isaac Pitman & Sons, 2 W. Forty-fifth St., New York City. 319 pages, illustrated. Price $6.

This book discusses the theory, design and practical application of the induction motor and has been prepared especially for designers, consultants and students. It goes, therefore, very deeply into the theoretical discussion of these subjects. An attempt has been made to deal with the latest developments in speed and power factor control, and to incorporate most of the theory connected with the motor and its application.

* * * *

Practical Radio—By James A. Moyer and John F. Wostrel. Published by McGraw-Hill Book Co., Inc., 370 Seventh Ave., New York City, second edition, 266 pages, illustrated. Price $1.75.

This second edition has been made necessary by the changes and remarkable development of radio equipment. Two of the important additions are the radio trouble chart and a chart which shows the important characteristics of various radio receiving sets.

Power-Factor Wastes—By Charles R. Underhill, Consulting Engineer. Published by McGraw-Hill Book Co., Inc., 370 Seventh Ave., New York City, 296 pages, illustrated. Price $3.50.

One object of this book is to acquaint those directly responsible for the large proportion of power factor wastes, and who pay the bills therefor, with how much these wastes cost, as reflected in actual savings, with a discussion of their causes and cures. The aim is to present as many sides of the question as practicable, with a thorough discussion, which reflects the opinion of a number of authorities.

The subject of power factor and its correction is discussed from the power user's standpoint, with details as to how the user can correct power factor and the advantages which will result.

The manner in which the subject is treated is shown by the chapter headings, which are as follows: Introductory; power factors, wires, and voltages; importance of keeping motors loaded; analyses of power bills; transmission, distribution, and rates; symposium of the power factor situation; fundamental principles of the power factor and its correction; some characteristics of induction motors; correction of the power factors of induction motors; the plant distribution system; synchronous machinery in power-factor correction; static condensers; correction of the induction motor with static condensers; capacitors; power-factor correction with Fynn-Weichsel motors; improving the power factor with the electric furnace; location of power-factor-corrective apparatus; status of power-factor corrections; statistical data; general and summary.

* * * *

Signal Wiring—By Terrell Croft, Consulting Engineer. Published by McGraw-Hill Book Co., Inc., 370 Seventh Ave., New York City, 338 pages, illustrated. Price $3.

This book has been prepared from the standpoint of the man who is to install the signal wiring and so is written largely from the standpoint of the considerations involved in laying out the circuits; no attempt has been made to discuss the design or manufacture of the devices themselves. Because the information which is ordinarily desired relates to the connection of the apparatus and the layout of the circuits, this book contains over 460 circuit diagrams which illustrate the various points brought out.

The different types of signal systems which are discussed and diagrammed are well indicated by the following chapter headings: Bells and annunciators; burglar alarms; hospital and hotel signals; time- and program-clock circuits; auto-call signaling circuits; telephone circuits; fire alarm circuits; watchman and police call circuits; power station signaling; water flow and pressure alarms; elevator signaling; mine signals; railroad signaling; miscellaneous signaling circuits; batteries, transformers and signaling devices. The sixteenth and last chapter, on "Signal Wiring Methods," gives the National Electrical Code requirements and in addition, discusses conductors and cables, their supporting and installation, lightning and excess-current protection, batteries, motor-generators and low-voltage transformers and other equipment used in installations of this character.

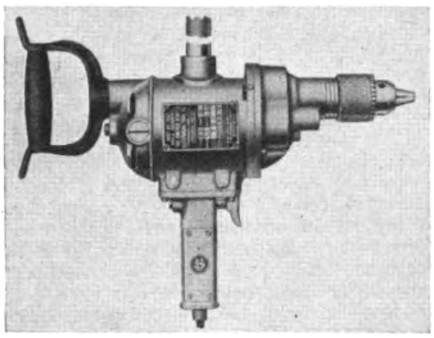
New Equipment

for plant operation and maintenance

Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these new devices which are designed to improve plant operation or reduce operating and maintenance costs.

Portable Electric Drills

TWO ½-in. portable electric drills have been brought out by the United States Electrical Tool Co., Cincinnati, Ohio. These are a ½-in. heavy-duty model, and a ½-in. special drill, which is shown below. The former is of heavier construction to stand up under more severe requirements. The latter is for general, all-purpose work.

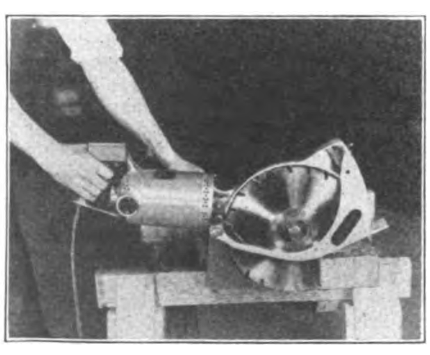


Both tools have a spade handle which can be removed by loosening either of two screws so that the drill can be secured to the adjusting screw of an "old man."

The motors are designed to operate the drills at 450 r.p.m., full-load speed. Three S K F ball bearings are used in these drills. A ball-thrust washer is placed behind the drill chuck. The motors are controlled through a trigger switch which has an "on and off" indicator; the "off" position is indicated when the arrow is crosswise to the line. Ventilation is provided for the universal motors which are designed to operate on direct or alternating current of 60 cycles or less.

Portable Motor-Driven Saw

ANNOUNCEMENT is made that the Crowe Mfg. Corp., 139 E. Third St., Cincinnati, Ohio, has placed on the market a portable motor-driven circular wood saw. This saw has a guard so arranged that it is impossible for the workman to remove the saw from

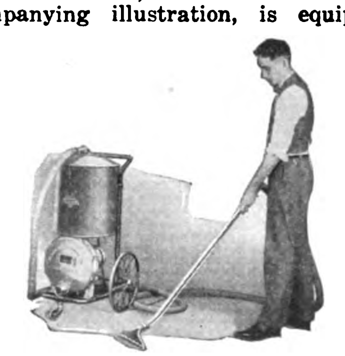


the board without the guard covering it and locking itself so that it cannot be removed until it is again on the board in a position for sawing. A trigger switch is so arranged that it must be held in contact to keep the saw running. This saw is made in three sizes that will handle practically any timber used in building. Universal motors are supplied for 110- or 220-volt service, which permits connection to any socket.

Portable Vacuum Cleaner

AN entirely new design of semi-heavy-duty, portable vacuum cleaner with dust-blower attachment has been placed on the market by the Allen & Billmyre Co., Inc., Grand Central Palace, New York City. This machine is used for light dust removal work in factories of various kinds and the dust-blowing attachment should make it a valuable acquisition for any plant using electrical apparatus.

This machine, as shown in the accompanying illustration, is equipped



with a ½-hp. Universal Westinghouse motor; it weighs 105 lb., and is very compact and ruggedly built. A machine for this type of work can be classified as coming between the small household vacuum cleaner and the heavy-duty portable and stationary cleaners.

Machine for Winding Springs

COIL springs for replacement may be made by the Rapid Spring Winder, which is a portable device to be clamped on a bench and operated by a crank. This device is announced by the Fostoria Screw Co., Fostoria, Ohio. It is possible, according to the manufacturer, for any one to make coil springs in any ordinary size, any length, and in either right- or left-hand lead or twist as desired.

The size of the spring is determined by the size of the mandrel used, while the pitch or lead of the spring is determined by the position of the little cam. This can be set in any position to produce a spring of any desired pitch.

Lever-Operated Master Switch

LEVER-OPERATED master switches for steel mill service or other work where strength and durability are important factors are announced by the General Electric Co., Schenectady, N. Y. The new switch is particularly suitable for grouping and for operation by one man. It has been assigned the designation C-3003 in the CR-3012 series of control equipment. The C-3003 master switch is flat and semi-circular in general shape and consists of a cast-iron frame and cover which totally enclose the contact mechanism. This design permits convenient grouping within easy reach of one operator.

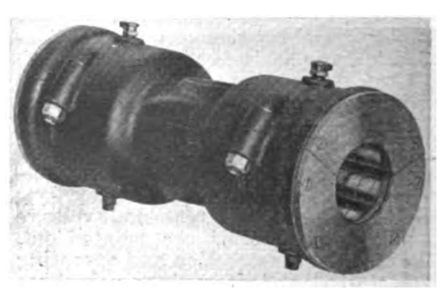
The handle is of the vertical type, operating through a radius of 40 deg. on a one-point switch and through a 100-deg. total radius on the three-point switch. Operation from one position to another is very free, it is said, as there are no gears or other friction surfaces other than the bearings and contact fingers. The handle is held in the "off" position by a spring roller device. This switch is made in several forms, the C3003-B shown above being standard.

Narrow-Center Hanger Bearing

LINESHAFT roller hanger bearings with a narrow center, which are designed for an exact size-for-size replacement box, have been announced by the Hyatt Roller Bearing Co., Newark, N. J. This bearing box is completely split for easy installation and fits any type of hanger. The distinctive, helically-wound rollers are retained. The box is of dumb-bell shape, as shown in the accompanying illustration, with twin split-roller assemblies mounted at each end. The center section, which is free from bearing surface, is narrowed down to average plain-bearing dimensions to fit hangers with narrow frame openings.

The box is built in two sections, the lower part forming two-thirds, and the top, one-third. This brings the machined joint well above the oil level and prevents oil leakage. Tightening four bolts, seals the sections around a shaft. Bosses are staggered so that the top cannot be improperly fitted. A small wrench is the only installation tool used.

The Hyatt Co. reports that one filling of lubricant every three or four months is the only attention this new bearing

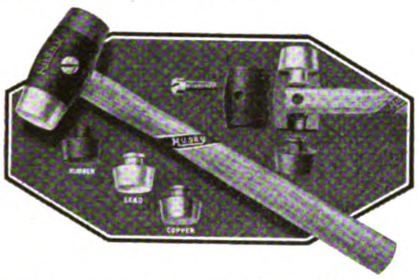


requires. Grit and other substances that tend to break down the oil film are drawn away from the bearing surface through the slots in the hollow rollers.

Manufacture at present is confined to five sizes, $1\frac{7}{16}$ in., $1\frac{15}{16}$ in., $2\frac{3}{16}$ in., $2\frac{7}{16}$ in., and $2\frac{15}{16}$ in., for which the demand has been greatest. For use with larger sizes of hangers requiring bearings up to $4\frac{15}{16}$ in., the old line of U. G. and B. & S. type Hyatt bearings are being continued.

Interchangeable Soft-Tip Hammer

PATENT and manufacturing rights to the interchangeable soft-tip hammer illustrated have been acquired by the Husky Wrench Co., 928 Sixteenth Ave., Milwaukee, Wis. The hammer is made in 2- and 4-lb. sizes.



Hammers are supplied with interchangeable soft tips of copper, lead, rubber or other material as desired. They are marketed in sets with two of each kind of tip. The tips can be replaced after loosening the filister-head screw and separating the housings.

Maintenance and Production Control System

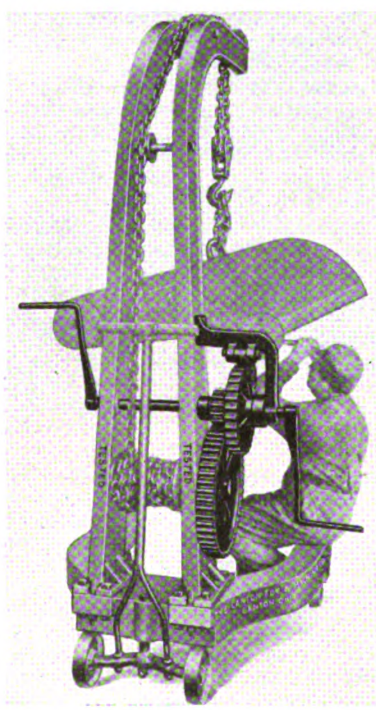
ANNOUNCEMENT is made by The Temporator Co., 548 Orleans St., Chicago, Ill., of the development of an electric signaling system for the control of production and operation, including maintenance, in industrial plants. This system consists of a central switchboard, one or more so-called service stations, and a number of dialing stations, similar to the dial on an automatic telephone, installed at the machines and in other locations in the plant. The central switchboard and a service station are shown in the illustration below.

The operation of the system is as follows: Through a scheme of code numbers the machine operator dials all desired information, such as the time of starting a job, notification that stock or raw material is getting low, requests for oiling, adjustment or other maintenance service, and so on. The code numbers conveying this information are shown through a number of little windows in the switchboard.

The switchboard operator records all incoming calls so as to determine time, cost, and production schedules, and also records and dispatches to the proper station all calls for maintenance service. The operator does this by flashing, from a dial on the switchboard, the number of the maintenance man and the code number of the service required on a conveniently-located, overhead visual placed in the plant department concerned. A bell also rings to attract the attention of the maintenance man. In answering the call he goes to his service station, jots down the number of the machine that requires attention and gives this machine the desired service.

Portable Crane With Load Brake

HERETOFORE, most cranes have been built with a ratchet and pawl, but the Canton Foundry & Machine Co., Canton, Ohio, has just developed and has ready for the market, a new improved Canton portable crane, with a safety friction load brake, which is shown in the accompanying illustration. It is stated that with this load brake on a crane, the load is held at any point; it can not under any condition get away from the operator; that this brake insures positive safety to the operator and to the work handled; and that it complies with safety regulations throughout the country.



This friction load brake operates by means of friction disks in connection with a helix and is so designed that the pawl is always engaged in the ratchet; it is necessary to wind the load down as well as to raise it. In this way, according to the manufacturer, the load cannot get away from the operator, whether or not he lets loose of the handle. This unit is built not only for new portable cranes, but is so designed that it can be installed in Canton cranes now in service.

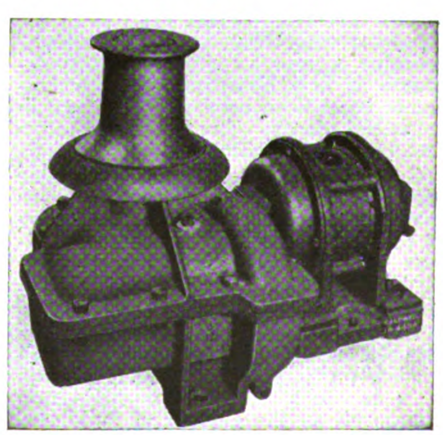
Vertical Electric Car Spotter

A NEW, vertical-capstan, electric car spotter, known as the Caldwell Car Spotter, has been announced by H. W. Caldwell & Son Co., 1700 S. Western Ave., Chicago, Ill. Twenty pounds pull on the capstan, it is asserted, will serve to move a ton of freight on a straight track and 3 min. with this machine suffices, usually, to do work that formerly took two men with pinch bars 30 min. to do. Other applications of this spotter include, besides pulling and spotting cars, the moving of materials in lumber yards, steel mills, foundries, in logging work, and on the docks. Many of these manifold uses are made possible, it is averred, through the 360-deg. working radius of the capstan, a feature which permits the reduction of hand labor.

Two sizes, Nos. 1 and 2, are announced by the manufacturer of this unit. The former size has a speed of 40 to 60 ft. per min. while moving one, two or three cars; and the latter size is said to move from three to six cars, at the rate of 26 to 42 ft. per min. The upper bearing of the vertical capstan shaft is especially long, to take the pressure from the rope pull. A cut-steel spur pinion mounted on the motor shaft meshes with a cut, cast-iron spur gear on the worm shaft. The worm is of hardened steel, integral with the shaft, running in roller bearings, and with a ball bearing for taking up the end thrust.

The Caldwell Car Spotter has an automatic oiling system which consists of an upper and a lower reservoir. The spur gear running in the lower reservoir, brings up the oil with it.

The worm gears, running in the lower reservoir, are lubricated by the oil thrown over them by the spur gears, and by the worm dipping into the circulating oil. This also lubricates the radial and thrust bearings on the vertical shaft. Three pet-cocks are provided to regulate the oil level. A grease cup is provided for the upper bearing on the vertical shaft.



Trade Literature
you should know about

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Polyphase Induction Motors—Bulletin 1132 describes the Types AR and ARY polyphase induction motors with cast-steel frames and Timken tapered roller bearings, which are available in ratings from 3 to 200 hp.—Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Floodlighting—Bulletin 216 contains a description and illustrations of the latest type of Golden Glow floodlighting equipment built by this company, with numerous charts and diagrams giving specific performance data.—Electric Service Supplies Co., 17th & Cambria Sts., Philadelphia, Pa.

Portable Electric Tools—Catalog 14 describes the line of Thor portable electric drills and grinders, screwdrivers and drill stands.—Independent Pneumatic Tool Co., 600 W. Jackson Boulevard, Chicago, Ill.

Ball Bearings—Catalog 20 devotes 48 pages to the description, illustration and rating of the various types of radial and thrust ball bearings for a variety of services.—G-A Ball Bearing Mfg. Co., 123-141 N. Albany Ave., Chicago, Ill.

Portable Elevators—A circular describes and illustrates a number of applications of the Revolvator, which is a portable elevator with a revolving platform.—Revolvator Co., 336-352 Garfield Ave., Jersey City, N. J.

Electrical Drives for Power Plant Auxiliaries—Motor Application Circular 7381, under the above title, devotes 24 pages to a discussion of types of motors and control for the various power plant auxiliary services.—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Switchboards and Synchronous Motor Starting Panels—Bulletin 111 illustrates various types of this equipment and describes the eight points of protection claimed for it.—The Ideal Electric & Mfg. Co., Mansfield, Ohio.

Lift Trucks—A group of circulars illustrates and describes the various models and sizes of Plimpton, four-wheel, hand-lift trucks.—The Plimpton Lift Truck Corp., Stamford, Conn.

Recording Units—Bulletin 266 entitled, "Recording Units for Use in the Purchase and Sale of Electricity," contains a number of interesting accounts of how Esterline-Angus instruments have been used to advantage in industrial plants.—The Esterline-Angus Co., Indianapolis, Ind.

Gravity Belt Tightener—A circular describes the Pulmax drive and gives a direct comparison of the operation of the open drive and a standard Pulmax drive for the same installation.—Bird Machine Co., South Walpole, Mass.

Window-Washing Equipment—A circular describes the Cleveland Tramrail window-washing system which consists of a car and trolley supported from a tramrail on the outside of buildings, to facilitate the washing of large window areas. — Cleveland Electric Tramrail Division of The Cleveland Crane & Engineering Co., Wickliffe, Ohio.

Separator Magnets—A folder describes the use of E C & M magnets for removing tramp iron.—The Electric Controller & Mfg. Co., Cleveland, Ohio.

Armature Winding Machines — A number of circulars describe the operation of Chapman armature winding machines of various types and capacities.—P. E. Chapman Electrical Works, St. Louis, Mo.

Lifting Jack—Form 803-C describes the line of Duff lifting jacks which are manufactured in capacities ranging from 1 to 75 tons.—The Duff Mfg. Co., Pittsburgh, Pa.

Galvanized Iron Paint—A circular describes Galvanum, which is a special paint designed for use on galvanized iron surfaces.—Goheen Corporation of N. J., Newark, N. J.

Electric Drills—Special bulletin G-30 describes the improved special ball bearing ½-in. drill with universal motor, and other standard portable electric tools.—The Standard Electric Tool Co., Cincinnati, Ohio.

Flexible Fixture Hangers—Folder 35 and Bulletin 2084 describe the line of Crouse-Hinds flexible fixture hangers and illustrate a number of methods of attachment. — Crouse-Hinds Co., Syracuse, N. Y.

Transformers — Bulletin 2051 describes and illustrates a number of the advantages claimed for the Pittsburgh film radiator for transformers.—Pittsburgh Transformer Co., Pittsburgh, Pa.

Ball-Bearing Motors—A folder describes Marble-Card ball-bearing, a. c. and d. c. motors which are built in ratings up to 75 hp.—Marble-Card Electric Co., Gladstone, Mich.

Bus Supports—A circular illustrates and describes some of the features of the Three-E indoor and outdoor bus supports.—Electrical Engineers Equipment Co., Chicago, Ill.

Manual Controllers—Bulletin 100 describes and illustrates the construction and operation of Clark manual controllers of an improved faceplate type which are built for heavy-duty service.—The Clark Controller Co., 1146 E. 152nd St., Cleveland, Ohio.

Enclosed Switch—Circulars describe the new 40,000 Series Square D enclosed, externally-operated switch which is designed for infrequent operation as in the case of entrance switches, disconnects, and the like.—Square D Co., Detroit, Mich.

Speed Reducing Gears—Catalog 22 covers the Smith line of worm speed-reducing gears on light transmission machinery. These speed reducers are made in ratings up to 5 hp. and the line of light transmission equipment, consisting of pulleys, shafts, bearings, and so on, from 1¼ in. down to ¼ in.—Winfield H. Smith, Springville, Erie Co., N. Y.

Fans—Small circulars describe the line of Peerless, a. c. and d. c., oscillating, non-oscillating, and ceiling fans.—The Peerless Electric Co., Warren, Ohio.

Ball Bearings—A 12-page booklet discusses the results which may be expected from the use of Norma Precision ball bearings in fractional-horsepower motors.—Norma-Hoffman Bearings Corp., Stamford, Conn.

Floodlight—A circular describes the new S-M general-purpose, water-tight, portable floodlight, which may be used either as an emergency light or for constant use under troublesome operating conditions. This unit is adjustable to any position.—Seidler-Miner Co., 316 E. Jefferson Ave., Detroit, Mich.

Speed Reducers—A booklet entitled "Modern Speed Reduction" lists ratings and specifications for the various sizes of worm and herringbone speed-reduction units from fractional horsepower rating up, which are manufactured and stocked in standardized units for immediate delivery.—Boston Gear Works Sales Co., Norfolk Downs, Mass.

Belt User's Book—A 70-page pocket size, handbook under the above title, contains some very interesting information on the installation and maintenance as well as the selection of leather belts.—J. E. Rhoads & Sons, 35 N. 6th St., Philadelphia. Pa.

Non-Metallic Gears—Publication F-4506-B entitled, "Salient Facts on Silent Gears," contains the latest recommendations of the American Gear Manufacturers' Association, including a number of formulas and tables, together with a description of the applications of Micarta gears.—Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

Automatic Self-Starting Induction Motor—Bulletin 110 describes and illustrates the construction and gives the characteristics of the operation of the Type AA, double squirrel-cage, automatic, self-starting induction motors which are built in sizes from 3 hp. to 100 hp.—The Ideal Electric & Mfg. Co., Mansfield, Ohio.

Electric Cranes and Hoists—A 20-page bulletin discusses Shepard equipment for steam and electric railroad shops. Another bulletin discusses the use of this equipment in the leather industry. Both of these are well illustrated.—Shepard Electric Crane & Hoist Co., Montour Falls, N. Y.

Maintenance Equipment Specialties—A circular describes new maintenance equipment specialties such as the Martindale electrical etcher for marking iron and steel articles, soldering transformers, the No. 13 light, portable commutator slotter, and Imperial cleaning liquid and paste.—The Martindale Electric Co., 11710 Detroit Ave., Cleveland, Ohio.

Cutting and Welding Torches—A 12-page catalog describes the various types of Milburn torches for acetylene welding.—The Alexander Milburn Co., Baltimore, Md.

Time Switch—A circular describes the Eureka time switch for automatically switching lights or power on or off.—Eureka Tool & Machine Co., 42 Walnut St., Newark, N. J.

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Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

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INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

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Trends that are being followed in solving

Problems of Steel Mill Operation

involving the use of electrical and mechanical power drive equipment, together with present tendencies in the conversion, distribution and application of electrical energy in the iron and steel industry

IN THE application of electric motors to steel mill main roll drives, there has been great activity during the past nine months. During the period Aug. 1, 1924, to Aug. 1, 1925, 105 motors totaling 236,375 hp. were sold for application to steel mill main roll drives. From Aug. 1, 1925, to May 1, 1926, 84 motors totaling 135,480 hp. have been purchased by the steel industry for its main roll drives. A list of the motors together with the names of the companies purchasing them is given on page 250.

The record of the past 1¾ years is certainly convincing proof that electric motors are now recognized throughout the steel industry as the standard for mill drives. Not only has their former competitor, the steam engine, ceased to be a competitor, but steam engines in existing mills are being replaced in ever-increasing numbers by modern electrical equipment. Companies in which extensive replacements of steam drive are under way are the Inland Steel Co., Carnegie Steel Co., Kokomo Steel Co., Colorado Fuel & Iron Co., and the Bethlehem Steel Co.

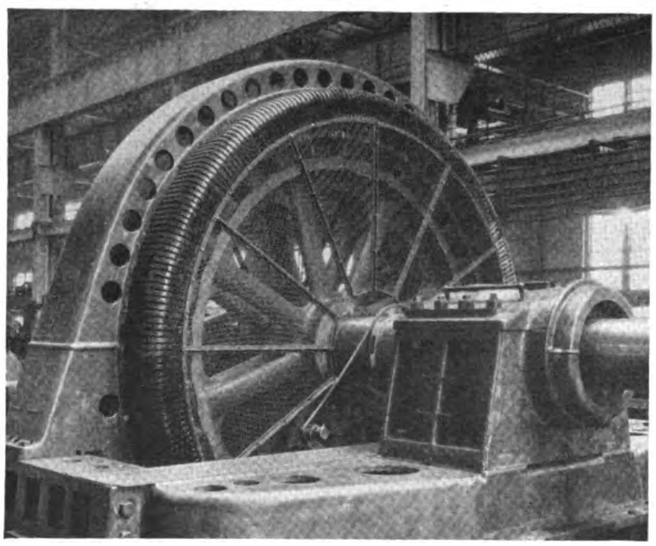
An interesting trend is the increased use of "frog leg" windings on large direct-current machines used in the steel industry. Since their introduction only a

By ARTHUR J. WHITCOMB

Associate Editor, Industrial Engineer

short time ago, 30 motors totaling 36,865 hp. have been sold to ten steel companies. It is interesting to note that a new 7,000-hp. reversing motor, which will be installed in the Chicago district, will have this winding on it; also that a 4,500-hp. motor with this type of winding has just recently been placed in operation in a skelp mill of a large pipe manufacturer.

The use of synchronous motors for main roll drives has received a decided impetus. A number of motors of this type have been used on seamless tube mills. The Globe Steel Tubes Co. has a 2,500-hp. unit. Also, a new seamless tube mill that is to be built in the Chicago district will have an 1,800-hp. synchronous motor on its main drive. An application of this character of especial interest is the motor now being erected by the McKinney Steel Co., which will drive a 10-stand, Morgan continuous sheet bar mill. This is a 9,000-hp. unity-power-factor, 107-r.p.m., 6,600-volt, 25-cycle synchronous motor, shown below, which, from the standpoint of continuous horsepower capacity, is the largest motor of any type used for industrial purposes in the United States or, so far as can be learned, in any other country. It is also notable in that it is the first really large synchronous motor to be used for driving a rolling mill. The motor may be started, stopped, or reversed from a master switch and automatic control panels exactly the same as any other type of rolling mill motor.



This motor has the highest continuous horsepower rating of any industrial motor in the world.

It is a General Electric synchronous motor rated at 9,000 hp., 6,600 volts, 107 r.p.m. and will drive a 10-stand Morgan continuous sheet bar mill for the McKinney Steel Co., Cleveland, Ohio. It is the largest synchronous motor in such service.

Important developments have occurred in the control of variable-speed, direct-current, compound-wound motors. Modern mills for the rolling of strip, skelp, rod, and merchant shapes, often consist of several groups of one or more roll stands, each group being driven by an individual,

direct-current, adjustable-speed motor. The cross-section of the steel is small, so that to conserve heat, the mills must be operated at high speeds, and the length of the piece is such that it may be in several roll stands simultaneously and for periods of several seconds. This makes necessary the very close speed regulation of the several driving motors in order to avoid excessive looping of the metal in between two stands. For this exacting service compound-wound, compensated, direct-current, adjustable-speed motors are being applied. For machines having a very wide speed range by shunt field adjustment, it is found that adjustment of the series field strength is required in order to have the same speed regulation at all speed settings. In several instances this adjustment has been made by resistance shunts across the series winding cut in or out by means of knife switches or contactors. Recently a scheme has been perfected whereby the compounding excitation is provided by an auxiliary field winding energized from a small exciter generator which is excited by the main armature current, thus exciting the main motor in proportion to its load. In this auxiliary field circuit there is used a multi-point rheostat which is mechanically connected to the operating mechanism of the main shunt field rheostat. Thus the compounding excitation is adjusted simultaneously with the main shunt excitation and by proper proportioning of the field resistances the speed regulation may be made practically flat for all speed settings.

Adjustable-speed motors are used on main roll drives in strip mills and quite a few strip mills are now under construction. One of particular interest is the 16-20-in. strip mill now nearing completion in one of the mills in the Chicago district. In this mill there are 14 roll stands, two of which are edging stands. The first four stands are roughing units and are driven through a lineshaft and reduction gear set by a 1,500-hp., 2,200-volt, wound-rotor induction motor. The two intermediate stands are driven through reduction gears by 1,500-hp., and 1,800-hp. 600-volt, direct-current, adjustable-speed motors. The remaining four finishing stands are individually driven by 1,800-hp., 600-volt, direct-current, adjustable-speed motors.

Each of the above-mentioned gear sets is composed of Sykes herringbone gears which are connected to the Westinghouse driving motors by means of Falk-Bibby flexible couplings. These gears run in oil that is fed to them under pressure and filtered by means of a Bowser lubrication system.

Very good use is made of the basement in connection with the ventilation and cooling of the motors and motor-generator sets. Instead of running individual air ducts to each motor and generator, it was found to be decidedly cheaper and just as efficient to put the whole basement under pressure, sealing all outlets except the places at which the busbars enter the motors and generators. These places are left open so that the basement air being under pressure will pass up through the

Motor-Driven Main Drives Purchased During Past Nine Months

Company	Mill	Drive	Motors		Volts	Cycles	R.P.M.
			No.	Hp.			
Bethlehem Steel Co.	Sheet Mill	Geared	1	1,250	6,600	25	250
	Tin Plate	Geared	3	1,250	6,600	25	250
Buffalo Steel Co.	Rail Rerolling	Direct	2	1,350	4,400	25	214/161
Carnegie Steel Co Youngstown, Ohio	•Hoop Mill	Geared	2	450	6,600	25	730
	Hoop Mill	Geared	2	700	6,600	25	490
	Hoop Mill	Geared	1	1,600	6,600	25	490
	Hoop Mill	Geared	1	770	6,600	25	440/540
	Hoop Mill	Geared	2	1,600	6,600	25	440/540
Carnegie Steel Co. Homestead, Pa.	52-in. Structural	Direct	2	2,000	700	d.c.	57/163
Colorado Fuel & Iron Co.	10-in. Merchant	Direct	1	300	600	d.c.	175/225
	Structural	Geared	1	3,000	6,600	60	450
	Structural	Geared	1	2,000	6,600	60	450
Columbia Steel Co.	Rev. Hot Strip	Direct	1	5,000	900	d.c.	70/150
	Hot Strip	Geared	4	2,000	600	d.c.	200/400
Conners Steel Co.	16-in. Mill	....	1	700	2,300	60	440
Crucible Steel Co.	22-in. Merchant	Geared	1	1,800	250	d.c.	550/650
	9-in. Merchant	Direct	1	700	250	d.c.	240/450
	9-in. Roughing	....	1	800	250	d.c.	200/450
	9-in. Roughing	Geared	1	500	2,200	60	884
	Bar & Billet	Geared	1	400	2,200	60	885
Donner Steel Co.	Bar	Geared	1	1,000	230	d.c.	210/510
Ford Motor Co.	18-in. Cont. Billet	Direct	1	5,000	13,200	60	99
Forged Steel Wheel Co.	40-in. Rev. Blooming	Direct	1	7,000	700	d.c.	50/120
Globe Steel Tubes Co.	Piercing	....	1*	2,500	2,200	60	257
Illinois Steel Co. Chicago, Ill.	Blooming Mill	....	1	7,000	700	d.c.	50/120
	12-in. Bar	Geared	3	500	600	d.c.	175/350
	12-in. Bar	Geared	5	1,000	600	d.c.	350/700
	12-in. Bar	Direct	2	800	600	d.c.	175/350
	12-in. Bar	Direct	3	800	600	d.c.	220/440
Inland Steel Co.	Rail Rerolling	Direct	2	1,000	4,000	60	225/168
	Rail Rerolling	Direct	1	400	4,000	60	514
	Sheet Bar	Geared	1	3,000	2,200	25	500/250
	19-in. Cont. Billet	Geared	1	7,500	2,200	25	368
Indiana Rolling Mill Co.	22-in. Finishing	Geared	2	300	2,200	60	505
Latrobe Electric Steel Co.	Merchant	Geared	1	400	440	60	870
	10-in. Merchant	Geared	1	500	440	60	900
McKinney Steel Co.	10-in. Merchant	Geared	1	1,000	600	d.c.	200/600
	10-in. Merchant	Direct	1	2,000	600	d.c.	134/275
	10-in. Merchant	Direct	1	1,200	600	d.c.	300/500
	12-in. Merchant	Direct	1	5,610	6,600	25	156/94
	12-in. Merchant	Direct	3	800	600	d.c.	200/415
	12-in. Merchant	Direct	1	800	600	d.c.	240/480
Penn Seaboard Steel Co.	12-in. Merchant	Geared	2	800	700	d.c.	275/550
	9-in. Merchant	Direct	1	800	700	d.c.	275/550
Pittsburgh Crucible Steel Co.	18-in. Roughing Mill	....	1	1,800	500	d.c.	350/640
	18-in. Merchant	Geared	1	600	250	d.c.	400/800
	12-in. Merchant	Direct	1	1,200	250	d.c.	160/320
	12-in. Merchant	Direct	1	500	250	d.c.	175/350
Sharon Steel Hoop Co.	Strip	Direct	2	1,200	230	d.c.	200/400
Southern Cal. Iron & Steel Co.	Merchant	Direct	1	1,500	2,200	50	300/175
Standard Seamless Tube Co.	Piercing	Geared	1	3,500	2,200	60	600
	Tube Rolling	Geared	1	1,600	2,200	60	600
Wheeling Steel Corp.	Sheet	Geared	1	1,200	2,200	60	277
Youngstown Sheet & Tube Co., Youngstown, Ohio	Seamless Tube	Geared	1	2,000	600	d.c.	230/360
	Seamless Tube	Geared	4*	450	2,200	60	720
Youngstown Sheet & Tube Co., Indiana Harbor, Ind.	Tin Mill	....	1	1,800	2,200	60	253
	Cold Roll	....	2	1,000	2,200	60	235
MILLS FOR METALS OTHER THAN STEEL							
American Brass Co.	Brass & Copper	Geared	1	600	550	60	360
	Brass & Copper	Geared	1	600	550	60	300
Anaconda Copper Mining Co.	Copper	Direct	1	800	2,200	60	450/225
	Copper	Direct	1	500	2,200	60	450
Mich. Copper & Brass Co.	Rev. Hot Copper	Geared	1	500	600	d.c.	360/612
	Copper Rolling	....	5*	800	4,600	60	720
The International Nickel Co.	Cold Strip	....	5	320	230	....	400/800
U. S. Aluminum Co.	Aluminum	Geared	1	500	2,200	25	500

* Indicates Synchronous Motor. For drives purchased prior to Aug. 1, 1925, see page 408 of the September, 1925, issue of INDUSTRIAL ENGINEER.

motors or generators and out into the atmosphere of the room above. Two blowers are located in an outhouse on the ground level of the floor above, which force air through Reed dry-type air filters into the basement.

An unusually interesting installation is being completed in the combination cross country and structural mill of a Chicago independent producer. The mill will have a reversing drive on two stands in tandem and three adjustable-speed drives on other tandem roll trains. The reverse drive is the standard arrangement using a 3,100-hp. motor supplied from a flywheel motor-generator set. There are two generators on this set, one of which supplies the reversing motor while the other supplies the three 2,000-hp. adjustable-speed motors.

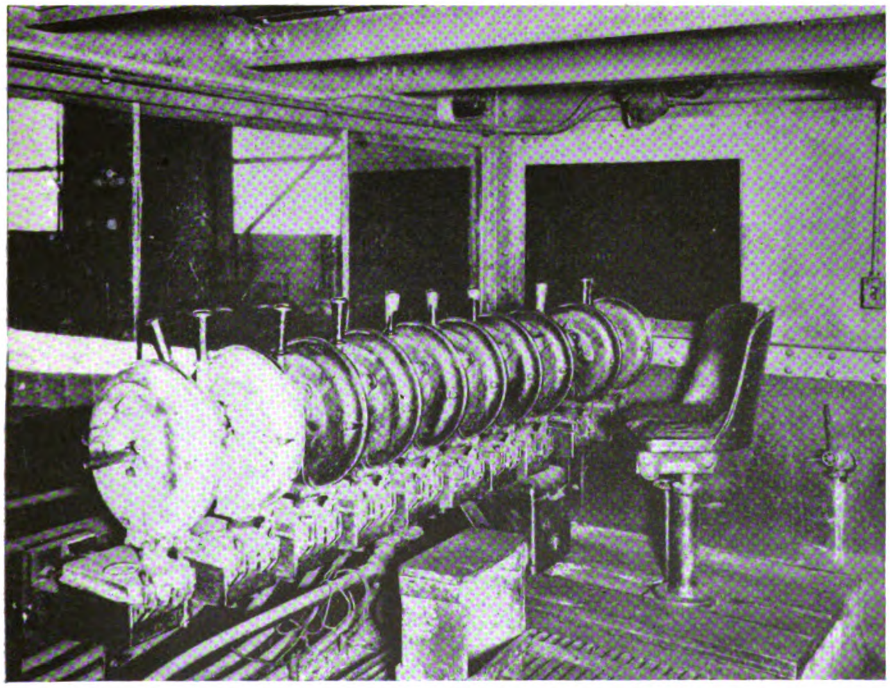
A feature of the control on the main motor is the fact that a special master has been built, which controls not only the reversing motor, but also the front and back mill tables. Cutouts are arranged for foot operation so that any of the above may be cut out and the remainder run separately. For instance, it might be desired to run the tables without the reversing motor so as to get the bar close to the roll train. In such cases the operator pushes a cutout switch with his foot, which cuts out the control of the main motor temporarily.

Improvements have been made in alternating-current, adjustable-speed drives by the development of a frequency converter type of equipment, arranged for double-range operation and having constant-torque characteristics. The main induction motor and the frequency converter, both on the same shaft, are the only two rotating machines required. The induction motor slip energy is converted to line frequency directly by the frequency converter, and returned to the line through speed-adjusting transformers. Three machines of this type, one of 770 hp. and two of 1,600 hp. each, are being built for hoop mill drives at the Upper Union Works of the Carnegie Steel Co.

A 3,500-hp., 700-volt, 50-120-r.p.m. reversing motor which replaced a steam engine on the 34-in. blooming mill at the Kokomo Steel and Wire Co., Kokomo, Ind., was put into operation during December, 1925. An interesting feature of this installation is the use of a large Falk-Bibby type of flexible coupling to connect the motor to the pinion stand. It is also of interest to note that air for the ventilation of the reversing motor is cleaned by a Midwest type of air filter of 30,000 c.f.m. capacity. Heretofore wet air washers have been used for this service, but there seems to be a growing interest by steel mill operators in the dry type of filter.

Operator's pulpit in a modern 40-in. motor-driven, reversing blooming mill.

The roller sits in the chair and controls the main drive motor from a foot-operated master switch. With his hands he controls the screwdown and main tables. A second man controls all of the remaining equipment. The master switches shown are of the Westinghouse plug type, which may be removed and replaced with a spare by loosening three wing nuts.



The McKinney Steel Co. of Cleveland, Ohio, will install five motors for driving a new 12-in. merchant mill. The roughing stands will be driven by the largest Scherbius equipment which has so far been built. The motor is rated 5,610/4,500/3,370 hp., 156/125/93.6 r.p.m., 6,600 volts, 25 cycles.

Confirmation of some of the present trends in the use of steel mill main drives is noted in the types of the 72 main drive motors sold by one manufacturer during the year 1925. Out of the total number of motors, 46 per cent were direct-current, adjustable-speed motors. In other words, 79 per cent of the main drive motors fell in these two classifications. This clearly indicates the trend in main drive motors. Also, out of the 32 alternating-current, constant-speed, main drive motors sold, 70 per cent of them were for 60-cycle service thus clearly indicating the trend toward the use of 60-cycle power in the steel mills.

An interesting trend which has been but slightly touched upon previously in this article is the use of dry-type air filters instead of the more common air washer for purifying the cooling air supply for motors and generators. Although the wet washer cools the air as well as cleans it (which is of advantage during the hot summer months) several engineers stated that they favored the dry-type air filter because it possesses greater simplicity.

Changes in Auxiliary Drive Equipment

The attempt to standardize mill-type motors as used on auxiliary drives is absorbing the interest of many steel mill engineers. For a number of years it has been considered desirable that all mill-type motors of a given size should have uniform mounting dimensions so that complete motors of different manufacture would be interchangeable.

With this object in view the Standardization Committee of the Association of Iron and Steel Electrical Engineers has met with representatives of the manufacturers of mill-type motors. This committee stated that the differences in the external dimensions of mill-type motors of different manufacture was so slight that the problem of standardizing the external dimensions should not be difficult. This committee also proposed to the manufacturers that the

present eleven frame sizes be reduced to eight.

Another consideration was whether the motor speeds should be increased. A questionnaire sent by the committee to the membership of the Association disclosed, however, that the present low speeds were strongly favored. Another point raised in the questionnaire was whether or not anti-friction bearings should be accepted as standard for mill-type motors. Replies indicated that those who had extensive experience with anti-friction bearings strongly favored their adoption while the majority of replies, based on numbers, indicated that motors equipped with sleeve as well as anti-friction bearings would be in demand.

At the Chicago Convention of the Association it is expected that a final agreement will be reached in regard to the points mentioned above as well as on the following: (1) Should mill-type motors be provided with bearings having sufficient thrust capacity to permit the use of single-spiral 7 to 10 deg. helical gearing? (2) Should the mill-type motor be arranged to permit the use of sleeve type or anti-friction bearings interchangeably in the same frame? (3) Should the armatures be built on a spider with a commutator mounted on an extension thereof? (4) Determination of standard sizes for shaft diameters, tapers, keys, keyways, and shaft tolerances.

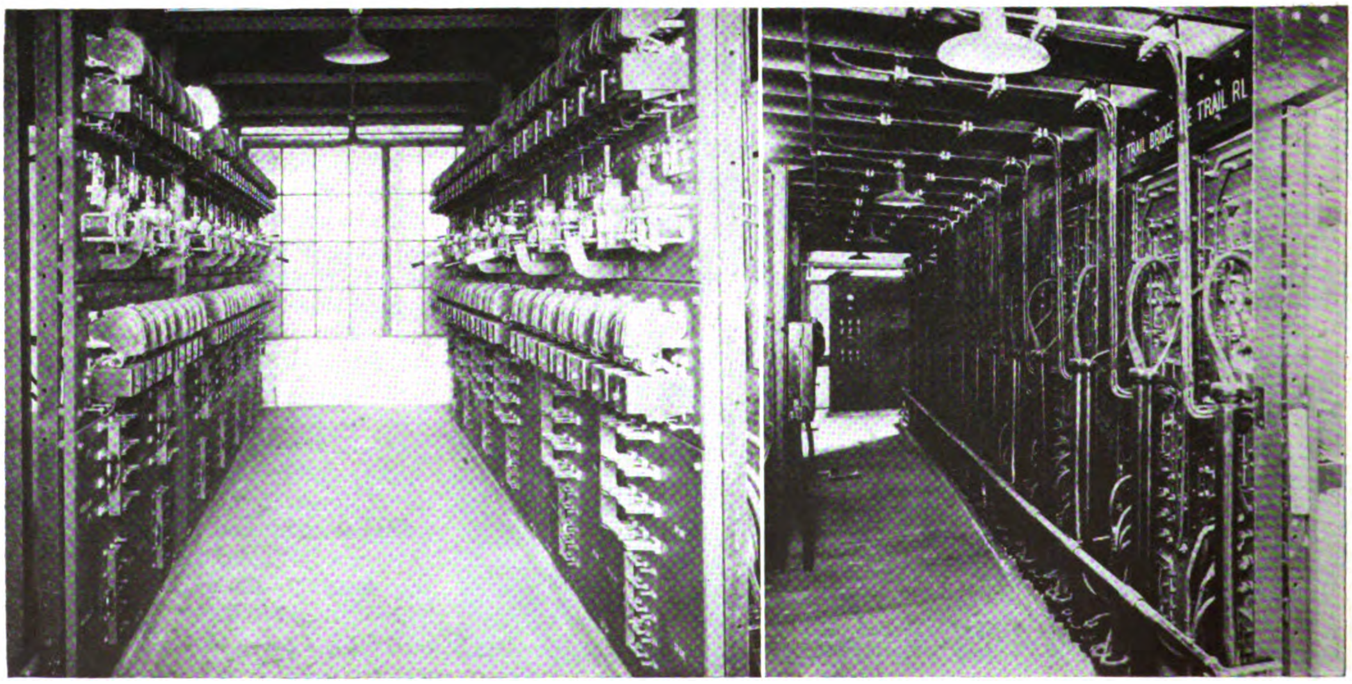
The use of mill-type motors on adjustable speed drives is increasing. One plant visited in the Chicago district is using mill-type motors exclusively on the drives smaller than 100 hp. in the welding end of its pipe mills. Motors in this part of the mill receive very severe service and are subjected to a great deal of dirt and dust and necessarily ought to be totally enclosed. Many of the drives in a pipe mill must have the speed controlled according to the size of product rolled. Consequently, general-purpose, shunt-wound motors have been commonly applied in the past for such applications. In the plant visited a special, compound-wound, mill-type motor is in use. These motors have a greater percentage of shunt field and a smaller percentage of series field than is the case with the standard compound-wound, mill-type motor. In many applications in a pipe mill, particularly so in the case of the cross rolls, close adjustment of the speed is required and this was being obtained with the motors just described.

This type of motor is also being installed in a new combination cross country and structural mill now being erected by a Chicago independent producer. Eight motors rated at 40-60 hp., 650-1,350 r.p.m. are being used to drive mill tables. The speed of the tables has to be varied in accordance with the speed of the main drives, which varies with the size of product rolled.

Another interesting auxiliary drive is the use of 95, ½-hp. squirrel-cage motors on the final run-out table in a new strip mill being erected in one of the mills in the Chicago district. Each roller in the table is driven by a separate motor and both the motors and the rollers run on ball bearings. The power for these motors is supplied from a generator that is belted to the last finishing stand main drive. By this arrangement the generator frequency always bears a definite relation to the speed of the last main drive, which in turn causes the table speed to automatically adjust itself in time with the main drive.

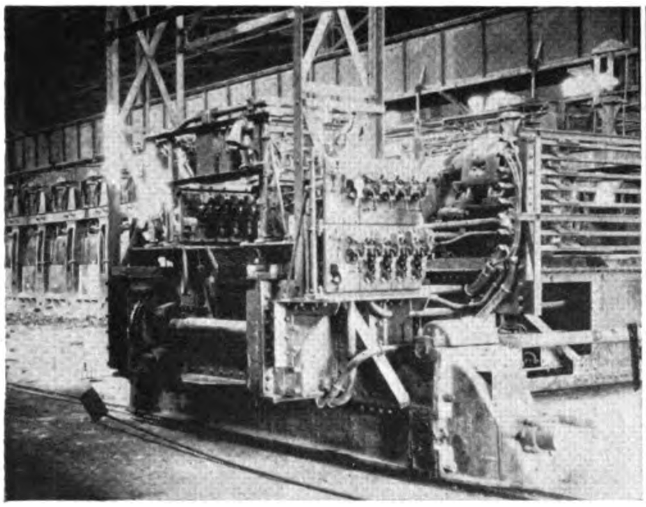
Trends in Installation and Use of Motor Control

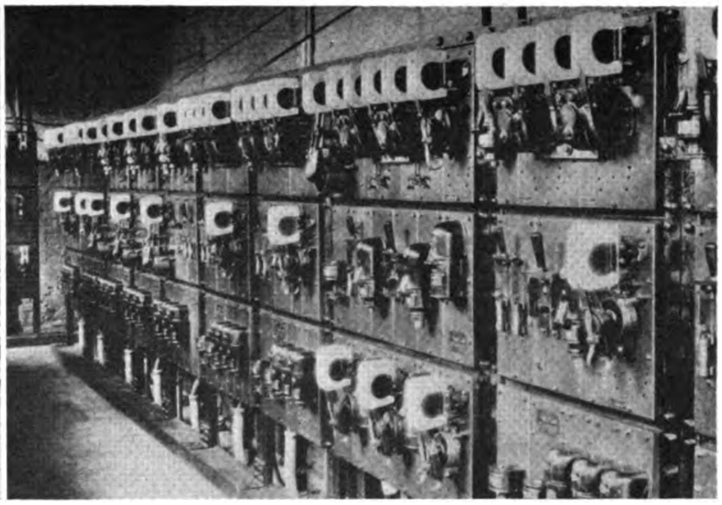
The question of what type of acceleration should be used for mill motor control is still a live one in steel mill circles. Although several methods have been developed, no one method is being adopted to the exclusion of the others. This is due to the fact that steel mill engineers have had considerable trouble with a method of control developed several years ago—most of which by the way, was due to incorrect application rather than to incorrect design—and as a result are conservative re-



The use of complete spare panels with transfer switches for quickly connecting them in circuit finds favor in some quarters.

This installation of General Electric magnetic time-limit control panels in the 35-in. structural mill of the Lackawanna plant of the Bethlehem Steel Co. is so arranged. As may be seen, four-pole, double-throw switches are placed on the bottom panels for transferring both the power and control circuits from the regular to the spare panel. The right-hand illustration shows a rear view of similar panels. No bus is used on this installation, power being brought in through the conduits terminating at the center of the panels. The resistor leads are carried open to a balcony directly overhead, while the transfer leads are carried in the horizontal conduit about a foot above the floor. The conduits terminating at the floor level are for the motor and master switch leads.





Two sturdy-looking installations of steel mill control.

At the left is an installation of Cutler-Hammer inductive time-limit control on an open hearth, floor-type, charging crane. The right-hand illustration shows an Electric Controller & Mfg. Co. installation in the new charcoal iron mill of the Reading Iron Co.

garding new methods of control. Probably the most widely used method of control at the present time is the current-limit type using series accelerating relays and shunt contactors. Practically all control manufacturers make this type of control and the newer types that they have brought out were developed with the idea of obtaining refinements that they felt should be expected from a motor controller. One manufacturer of both time and series relay control states that he notes a large increase in the sale of his new time-limit controllers, indicating a swing-over in favor of this type of acceleration, but on the other hand he has not noticed a falling off in the volume of sales in his series relay control. This is probably due to the increased volume of business over that of previous years rather than an increased demand for this type of control.

The time-limit method of acceleration has a large following—some plants prefer it to the exclusion of other types. This type of equipment is now made in both the dashpot and the magnetic types. The dashpot type, being the first method developed using the time-limit principle is consequently widely used. The magnetic and the inductive types are more recent developments but are rapidly receiving recognition among the mill operators and even now probably have a wider use than the dashpot type.

The inductive time-limit type, however, is more than a straight time-limit method of acceleration. This type of controller is said to give positive, time-limit acceleration until the motor armature starts to revolve after which current-limit features combine with time limit to govern the acceleration. For this reason it is said that with this type of control the inrush and accelerating currents can be set for minimum or average load, thereby reducing the heating of the motor and limiting the breaking of the heavy current by line contactors. Another feature claimed for this type of control is that it is impossible for a stalled motor to remain on the line, and that the plugging contactor is positively locked out until the motor armature comes to rest. It is also pointed out that with this type of control it is possible to adjust accurately the acceleration current and time at the factory.

Increasing use is found in the case of the magnetic type of time-limit control. In the Chicago district alone sales approximating $50,000 have been made of this type of control for use in the plants of two companies.

A noticeable tendency in application of motor drives is the growing use of two or more motors in parallel and connected together mechanically. These duplex drives are used on screwdowns, mill tables, on the bridge drives of ladle cranes, charging machines, and trolley and bridge drives of ore bridges. The advantages of the duplex system of control for these drives are being recognized.

Briefly, this system uses reversing and accelerating contactors of double-pole construction, each pole controlling the circuit to one of the two motors, and using separate acceleration resistors so that the motor circuits are kept entirely separate. Duplex control so designed is said to provide uniform peaks of current during acceleration and to cause the motors to divide the load evenly while running. The use of separate resistors also prevents destructive circulating currents when the motors are plugged.

This same system has also been extended to control four motors operating in parallel. Such is the case when four motors on the four legs of an ore bridge must be accelerated in exactly the same time so as to give an even operation. This is obtained by the use of four-pole contactors. The Electric Controller & Mfg. Co. has used this scheme of control on the bridge motion of the ore bridge just completed at the Indiana Harbor plant of the Inland Steel Co. and also on an ore bridge that has just been completed at the Central Furnace Co. plant.

The enclosing and housing of control equipment is receiving more attention than formerly. Where it is possible to group together the controllers for a given section of a mill, a control house is built and the controllers mounted therein, either on two separate floors or on one floor with a balcony for the resistors, as shown at the bottom of page 252. This method, while affording the most protection to the equipment and making it most accessible for inspection and maintenance, is quite expensive and often involves more wiring and longer conduit runs than if the controller were located nearer the motor. At the newest plant in the Chicago district, the control panels are located as near the motors as practicable, only the master switches being grouped in the various pulpits. The control panels, however, are totally enclosed in substantial steel cabinets with large doors at the front and rear. These cabinets are large enough to receive the resistors which

are placed on the floor below and immediately behind the panels. This method of installation provides a cheaper alternative than the control house scheme and yet affords good protection to the equipment and safety to the mill workmen.

In many mills it has been the more usual practice to install the control panels for the hoist and bridge motions of a crane in the crane cab. This, of course, necessitates a larger crane cab than would otherwise be necessary, but has the advantage of having the panels close to the master and at the point from which the cranes are controlled. However, a crane cab costs money and an enlargement to take care of the panels is somewhat expensive. Also, the space available in the crane cab is held down to the smallest amount needed to take the control and, consequently, the control panels might be somewhat cramped for space. On all of the cranes used inside of the buildings of a large pipe manufacturer in the Chicago district the standard practice is to locate the crane hoist and bridge control panels on the bridge walkway of the crane, where there is ample room for them.

The illustration shown on page 251 is a view of the operator's pulpit for a new 40-in. electrically-driven reversing blooming mill. The roller controls the screwdown and main tables by means of three master switches, and also controls the main reversing motor by means of a foot-operated master controller. The second operator controls the side guards, manipulators, and approach and run-out tables. The use of foot-operated master controllers reduces the pulpit crew of a blooming mill from three to two men, and also permits of increased production as the concentration of control in two men more closely co-ordinates the many operations involved.

The illustration just mentioned also shows the use of plug-type master switches. The receptacle into which these masters are plugged is arranged for rigidly mounting at the back of an angle or channel section. This leaves the space under the master switch open and is an improvement over mounting the switch on a conduit supported from the floor. The five leads from the master switch terminate in wedge-shaped fingers which engage in corresponding receptacle terminals when the master switch and plug are placed on the receptacle. By loosening three wing nuts the plug and master switch may be removed and a spare master switch substituted.

An innovation in automatic control is being used on eight of the mill tables of a combination cross country and structural mill now nearing completion. These eight motors are controlled by eight flag master switches placed on the tables in such a position that as the steel passes through the main rolls, it will hit the flag master, thereby causing the next motor to operate. Also, as the steel leaves a given table it will release a flag master and thus stop the table. Inasmuch as this scheme is used on eight tables it will greatly reduce the number of operators that would otherwise be required.

A new design of slip regulator has been developed for steel mill service which does away with external electrode cells. A novel feature of the new design is the complete enclosure of the cells so that the possibility of leakage of the electrolyte is eliminated.

Trends in the Application of Mechanical Elements of Power Drives

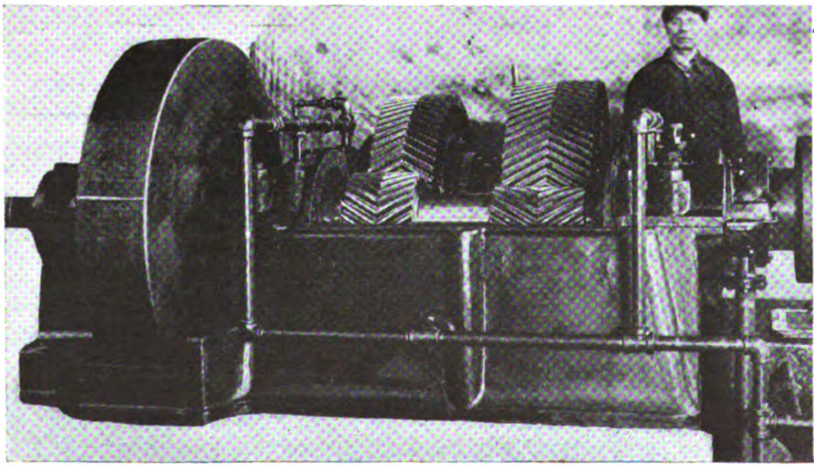
Anti-Friction Bearings—That the trend toward the universal use of anti-friction bearings is becoming very pronounced indeed, is the opinion of many steel mill engineers who were interviewed. Probably one of the largest installations ever attempted is now being made on the cranes in a new mill in the Chicago district. This company is making an installation of 20 cranes which are to be completely equipped with roller bearings. Rollway bearings are used for the motors, Hyatt roller bearings support the lineshafts, and Timken bearings are used on the axles and end trucks on these cranes. This installation of cranes will be watched with great interest, for the results secured will have a definite bearing on the universal application of anti-friction bearings to cranes.

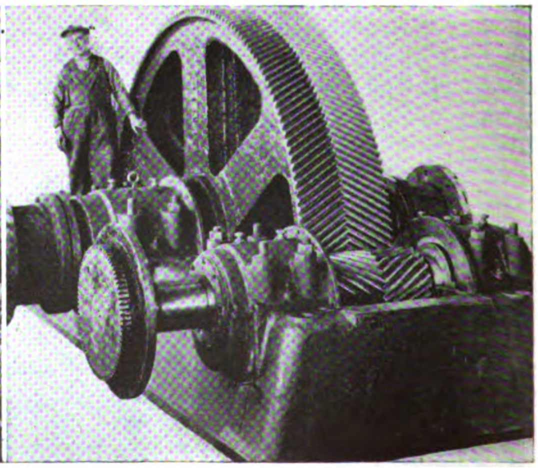
Another interesting installation of roller bearings has been made on an ore bridge recently built for the Central Furnace Co. of Massillon, Ohio. Roller bearings are used on all of the motors on this bridge, and in addition, roller bearings are used on all bearings on the trolley and hoist motions.

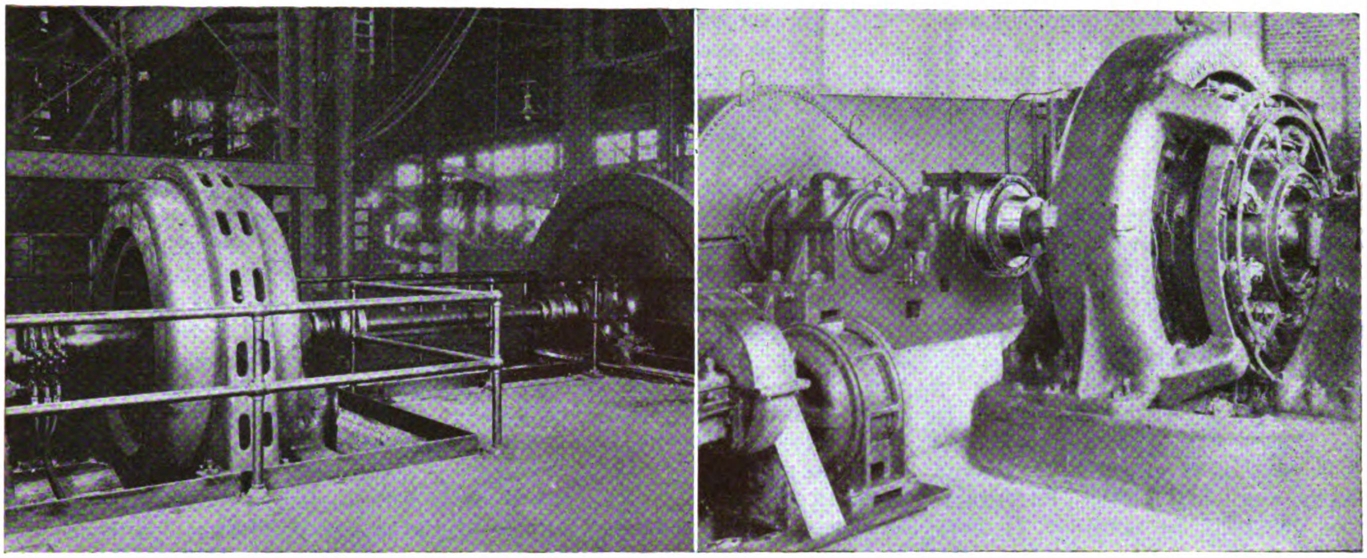
In the pipe mills of a large producer there are now in service approximately 300 sets of ball and roller bearings. These bearings are in use on general-purpose motors only, sleeve bearings being used on all mill-type motors. These bearings have been in service for over a year and to date not one operating failure has been experienced.

Two gear drives that are of particular interest.

On the left is shown a two-speed gear drive made by Farrell Foundry & Machine Co., that is used in connection with a bar mill of the Latrobe Electric Steel Co. permitting the use of a standard high-speed, 500-hp. motor running at constant speed. At the right is shown one of the reduction gear units made by the Farrel Foundry & Machine Co. for the new 16/20-in. strip mill of a Chicago plant. This gear will be used in connection with a 1,500-hp., 720-r.p.m. motor and has a ratio of 9 to 1. It is connected to the motor by means of a Falk-Bibby coupling.







Flexible couplings are becoming standard equipment on most types of steel mill drives.

At the left is shown a Fast flexible coupling with rigid halves and connecting shaft on a drive in the Glassport (Pa.) plant of the Pittsburgh Steel Co. On the right is illustrated a Francke flexible coupling connecting a Crocker-Wheeler adjustable-speed motor to a gear drive.

All of the auxiliary motors in a new rolling mill for handling alloy steel in the Chicago district will be equipped with roller bearings. Inasmuch as there are over 70 motors in this one mill, the installation is worthy of special mention.

Flexible Couplings—It has become almost standard practice, particularly in the more progressive plants, to use flexible couplings on all auxiliary drives such as roll tables, transfer tables, conveyor drives, hot and cold saws, fans, hoists, door machines on heating furnaces, screwdowns, manipulators and sideguards. Flexible couplings are being used to compensate for initial misalignment of shafts, wear of bearings, foundation settling, deflections of shafts, and distortion due to temperature changes and other uncontrollable conditions. One engineer interviewed favored the use of flexible couplings because in the case of gear drives, the reduction gear would be an independent unit to which the motor would be coupled by means of a flexible coupling, instead of having a motor pinion as part of the reduction gear and depending on the motor foundation bolts to keep the motor pinion in line with its gear. Still another reason advanced by a steel mill electrical engineer in the Chicago district is that the use of flexible couplings keeps the motor quite a distance away from the gears, which in turn eliminates a great deal of the trouble from oil getting into the motors; in his experience this feature was well worth the cost of the coupling.

There are several types of flexible couplings used in steel mill service and no particular type as yet seems to be preferred. One consulting engineer expressed a preference for a coupling that was capable of absorbing shocks, such as the Falk-Bibby or the Nuttall couplings. An operating engineer in the Youngstown district expressed a preference for the internal-gear type such as the Fast and Poole Engineering & Machine Co. types, while other operators are using pin types, such as the Francke, Thomas, and the like.

Flexible couplings are also used on many main drives, especially if there is a reduction gear between the main drive motor and the roll stand. A good example of this practice is in the strip mill of a Chicago plant where all except the last four stands are driven through Sykes reduction gears, which are connected to the motors by the Falk-Bibby couplings.

There have been numerous developments and improvements made in flexible couplings during the past year, especially in those designed for heavy-duty service. A special adaptation of Fast's flexible coupling has been made to fit the long tapered shaft ends of mill-type motors such as generally are used on steel mill auxiliary drives. This new design is arranged so that the coupling can be quickly disassembled and removed in the least possible time and thereby facilitate quick changes of motors in case of necessity. One hub of the coupling is made to fit the full length of the tapered shaft of the motor and is held in place by the locknut on the end of the motor shaft. The bolts on the flanges of the coupling halves are not shrouded like the standard coupling but are exposed and are fewer in number, thus being easily loosened and removed with an ordinary wrench.

Improvements have also been made in the Francke coupling. In comparison with the old Heavy Pattern Type, the improved coupling has cylindrical contact surfaces which give more than double the old contact surface; also the movement is between steel and bronze, and the graphited bushings used present a self-lubricated surface that is said to retain its lubricating qualities for many years. These new features are said to give more and easier endwise movement, increased capacity and longer life at all speeds.

The Poole Engineering & Machine Co. has also brought out a new flexible coupling. This is of the internal-gear type and it is said that it has been so designed that it is stronger than the connecting shaft and can be used on any shaft without consideration of a utility factor.

Gears — The use of heat-treated pinions is becoming almost universal mill practice and the use of heat-treated gears is increasing so rapidly that their adoption will be practically universal within the limits of the sizes that can be heat-treated. Undoubtedly, the hardness and toughness of the steel used in gears is of the greatest importance. Within certain limits the harder the material the better. There is one danger, however, which should be carefully guarded against. Some gears, after hardening, have been found to be warped excessively. This has resulted in inaccuracies in the teeth, which inaccuracies have caused more

severe stresses to be set up than could be withstood by virtue of the increased hardness and toughness of the material. In such cases the heat-treating of the gears has defeated its own object.

The specifications calling for hardened gears should always receive most careful attention. In the case of rolling mill pinions, hardened teeth are undoubtedly desirable. In the case of main drive gears, however, each installation must be considered from the standpoint of whether it is possible to harden the teeth with such a small amount of distortion as to gain real advantage. With auxiliary drives, advantages can generally be obtained by heat-treating, because the tooth velocities are generally not very high. Even in rolling mill pinions the tooth velocity should receive consideration when deciding on the method of hardening.

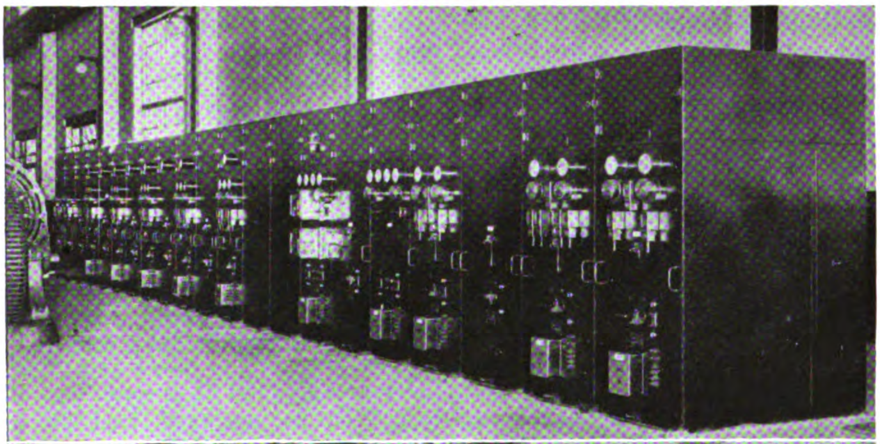
A new blooming mill soon to be erected in the Chicago district will have heat-treated pinions on all of the auxiliary and crane drives. The electrical engineer in a steel plant visited by the writer stated that all motor pinions and gears bought separate from a gear reduction unit as used in his new mill, were heat-treated. The same expression was heard from many of the other engineers interviewed.

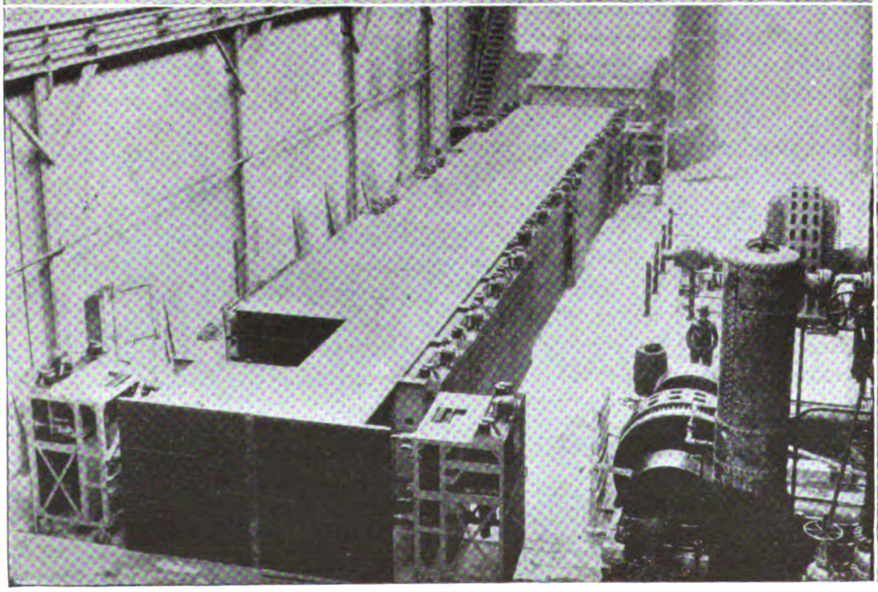
Consideration is being given to the use of single helical gears on auxiliary drives. Because of the "screw in" action of the helical tooth as compared with the straight spur tooth, its operation is considerably more quiet, reducing the noise and vibration in the gearing and correspondingly improving the action of adjacent parts of the equipment which would be affected by gearing that did not run smoothly. Spur gears give excellent results and smooth operation when running in properly maintained bearings and under reasonable supervision.

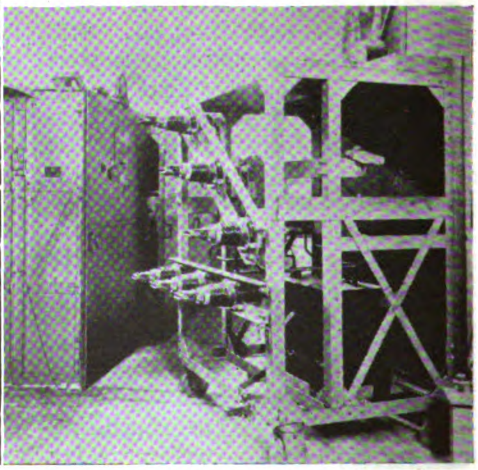
The use of single helical gearing has many advocates and also some opponents. One steel mill engineer interviewed stated that he did not favor its use on reversing drives because of the reversing end thrust. This matter of end thrust is being considered by the Standardization Committee of the Association of Iron and Steel Engineers in standardizing the mill-type motor.

For nearly all main drives requiring a motor of 150 hp. or more, herringbone gears are used for the gear reduction. Statistics made by one manufacturer of herringbone gears indicate that over 50 per cent of all the main drive reduction gears installed during 1925 were made up of herringbone gears of his manufacture. The tendency in steel mills is to apply herringbone gears having teeth with a 30-deg. helical angle.

Speed Reducers — In all of the mills visited, a large increase in the use of speed reducers was noted. Different operators offer reasons why they are using them. The main reasons given are: The self-contained reducer is more efficient, more durable, and more reliable; use of the reducer permits high-speed motors to be used and thus enables the engineer to choose the most efficient and economical motor speed while at the same time giving him the desired machine speed. Also, speed reducers have become so well standardized that they can be manufactured in comparatively large quantities and, therefore, produced at an economical price. Other reasons advanced were the small space occupied, freedom from lubrication troubles, adaptabil-







The use of truck-type switchboards is rapidly increasing.

The top illustration shows a safety, truck-type switchboard consisting of twenty-one 6,600-volt panels in the Woodlawn plant of the Jones & Laughlin Steel Corp. All equipment including the control station is located on these trucks. In the lower left-hand illustration is shown a Westinghouse truck-type switchboard in a skelp mill. This installation consists of 38 trucks arranged back-to-back to form a double-bus system. All trucks are designed for 6,600-volt service. The circuit breakers on the trucks are remote-controlled from a switchboard at the other end of the substation. The illustration at the right shows a close-up view of one of the two trucks carrying auto-transformers for starting the motor-generator sets.

ity to exceptionally dirty locations, and safety to workmen.

A two-speed gear drive for rolling mill application has been developed by the Farrel Foundry & Machine Co. and the one shown in the illustration, at left, on page 254 is used by the Latrobe Electric Steel Co. in a 10-in. bar mill. It is designed to transmit 500 hp. with a motor speed of 860 r.p.m. and to give a high speed of 275 r.p.m. to the mill and a low speed of 165 r.p.m. The desirability of a variable-speed drive for a bar mill is well understood, and it is relatively common to employ for this purpose a variable-speed motor. Such motors, with the necessary control apparatus, are expensive. The new gear drive allows the use of a standard motor, which can run at a relatively high speed. The flywheel on the pinion or motor shaft can be designed for the high speed of the motor instead of for the low speed, as is necessary when a variable-speed motor is used. This saves expense and results in better operating conditions, because the flywheel is always working at maximum speed and, therefore, it is always capable of storing or giving out the maximum amount of energy in proportion to its weight.

No one type of speed reducer is favored to exclusion. One large steel plant visited is using many of the planetary spur gear type while in the plant of a large pipe manufacturer in the Chicago district, from 500 to 600 worm gear speed reducers are in use.

Lubrication—The tendency regarding lubrication is more and more towards the complete enclosure of gears. The best practice is to mount the gears in a self-contained gear casing, which has both the pinion and wheel bearings integral. Pressure-feed lubrication is also being more widely adopted, and with excellent results. More care is taken in handling and filtering the oil. In one of the mills in the Chicago district, an elaborate Bowser oil system has been installed for purifying and supplying the oil under pressure to the reduction gear units used in the strip mill.

There is an undoubted tendency towards the use of more grease lubrication on many types of drives. On the installation of 20 roller-bearing-equipped cranes previously mentioned in this article, grease lubrication is used exclusively, the Alemite pressure system being employed.

In connection with a continuous bar mill now being erected it is interesting to note that all of the bearings on the main drive motors, reduction gears and lineshafts, as well as the motor-generator sets, will be arranged for forced-feed oil lubrication and each bearing will be equipped with a thermostat which will be connected to an annunciator. When the temperature of any bearing reaches the danger point, an alarm will be sounded and the annunciator will indicate which bearing is at fault.

Progress Made in Substation and Distribution System Design

Automatic Substations — Increasing use of automatic substations in the steel mills is one of the trends in the use of power equipment in this industry. Not only is automatic equipment applied to motor-generator sets, but also to the control of alternating-current and direct-current feeders.

So far there have been 24 equipments applied to motor-generator sets in the steel mills, controlling over 16,000 kw. capacity. The Youngstown Sheet and Tube Co. has recently purchased automatic equipment for five synchronous motor-generator sets, together with automatic equipment for d.c. feeders.

An automatic substation of especial interest was placed in service during January at the Homestead plant of the Carnegie Steel Co. This consists of two 1,500-kw., 250-volt, synchronous motor-generator sets, with provision for a future set, together with the complete automatic switching and control for these sets and for twelve 4,000-amp. feeders. This substation supplies power to the auxiliaries of the new blooming and structural mills, and is located in the main motor room which now houses two large main drive equipments, to which in the near future will be added seven more large motors for the drives. Even in this attended substation, it was deemed desirable to install automatic equipment as it was felt that the fewer delays in operation would amply pay for the higher investment.

Truck-Type Switching—The use of safety-enclosed, removable truck-type panels for controlling the main a.c. power feeder circuits in steel mills is steadily increasing. The ease of installation and low cost of maintenance, safety to operator and attendants in operation, repair and inspection, easy replacement of a unit when required either on account of a defective unit or for inspection, and the complete enclosure of all high-tension apparatus, connections and buses, are some of the principal advantages that are leading steel companies to adopt the truck-type switchboards.

One manufacturer alone has supplied 208 trucks carrying circuit breakers ranging in capacity from 300 to 2,000 amp., and in potentials from 2,300 to 12,000 volts. A large order recently placed by the Forged Steel Wheel Co. includes 41 circuit breaker trucks with steel housings and switchboard panels for the control of five synchronous motor-generator sets, two flywheel sets for main drive, reversing motors, power transformers, and several tie and feeder circuits to other substations.

An interesting installation just being finished in a mill in the Chicago district includes nine 2,300-volt trucks and four 12,000-volt trucks. These are located at one end of the substation in which are also placed the motors and motor-generator sets. No concrete cell structure is required, only the steel casing, similar to that in the illustrations at the bottom of page 256, is needed. All of the circuit breakers on these trucks are remote-controlled from the regular switchboard installation.

The largest truck-type installation that has so far been made consists of 38 circuit breakers and two auto-transformer trucks and is located in the new plant of a pipe manufacturer in the Chicago district. All of these trucks are for 6,600-volt service. The installation is illustrated at the bottom of page 256. Inspection will show that it is arranged as a double-bus system with duplicate switches on each feeder. This is for flexibility in switching. Two of the trucks have been withdrawn from their enclosures so as to show the circuit breakers. These breakers are remote-controlled from a switchboard at the other end of the room.

A recent development in switching that will interest many steel mill operators is the announcement that the Allis-Chalmers Manufacturing Co. has secured the exclusive right to manufacture the Reyrolle Armorclad Switchgear. This switchgear, like the truck-type switchboards, eliminates all cell structure for the isolation of busbars, transformers, disconnects, etc. The switch-house resolves itself into a simple shelter for the switchgear. All conductors,

including the busbars, are enclosed within grounded metal coverings. These coverings are such as to prevent the throwing out of flame, or hot gases, or the escape of gases in quantities and at points where mixture with the surrounding air might result in explosion.

Power Factor—Power factor continues to worry some steel mill operating men, especially those who purchase power. One plant having poor power factor has just completed a tandem strip mill using the Ward-Leonard system with adjustable-speed motors. This plant expects to improve its power factor by the additional load obtained from the synchronous motor-generator sets supplying the adjustable-speed motors.

A large independent mill in the Chicago district that purchases practically all of its power, has a power factor between 90 and 92 per cent lag, because of the five over-excited motor-generator sets that it has in operation.

During the past year a static condenser installation of 480 kva., 2,300 volts, has been made in the Western Reserve plant of the Youngstown Sheet and Tube Co. We are advised that the installation has practically paid for itself in 6 mos.' operation by the reduction in purchased power bills, and that the operators are very much pleased and enthusiastic over the success of this equipment.

Distribution — The distribution system used by a large pipe manufacturer in the Chicago district offers many features of interest as well as methods of saving on the initial investment required. At this plant there are three voltages that are carried through the mill buildings for supplying the auxiliary drives and the lighting circuits. These are 250 volts d.c., 220 volts, three phase a.c., and 110 volts, single phase, a.c. The various mill buildings in this plant are arranged in two groups, one group containing the skelp mill buildings which are arranged side by side and the other group containing the pipe mill buildings. The pipe mill buildings are arranged adjacent and parallel to each other, with a long aisle extending crosswise through the center of all of the buildings. The substation for the pipe mill buildings and likewise the substation for the skelp mill buildings is located at a central point in each group of buildings and adjacent to the aisle extending crosswise through the buildings. Instead of running cables from the switchboards in the substation to the various mill buildings, the following scheme was adopted:

Busbars are used to carry the 250-volt d.c. and 220-volt a.c. power from the switchboard in the substation through the basement to the central aisle and up the wall of the central aisle to a point just even with the eaves of the building. These buses are arranged vertically one over the other, each bus being supported by a horizontal busbar support and braced on top and below by a busbar insulated spacer. This method of mounting holds the buses together rigidly; also, the use of the busbars provides the heavy carrying capacity required. At the eaves of the building, at the end of the busbars, rubber-insulated cables are connected and are carried both ways along the central aisle to the various mill buildings. These cables are carried on porcelain insulators and fastened to the roof trusses. As the cables are above the crane runway, it is impossible for anything to come in contact with them.

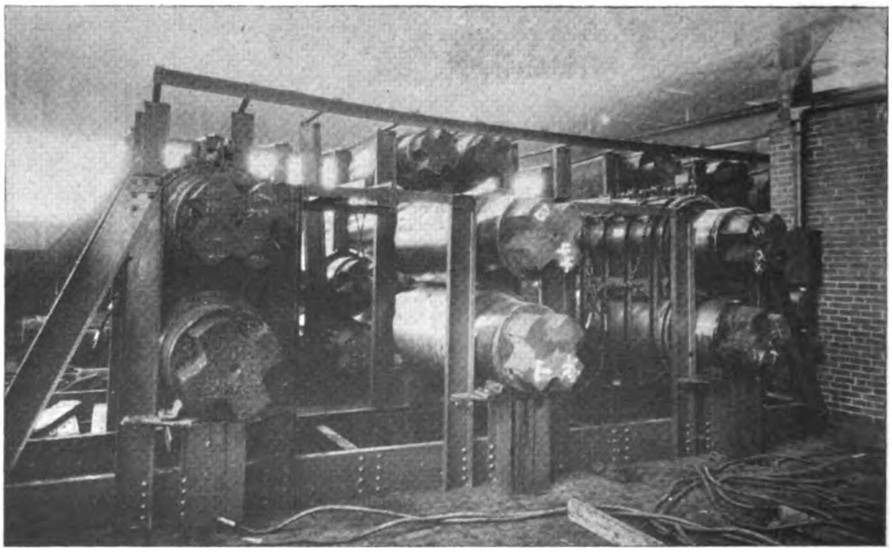
This open construction was favored, first, because it was a less expensive form of construction; second, the cables are protected for they are up near the roof where nothing could strike them; third, it provides the most flexible arrangement for making taps to any desired point in the building; and fourth, it is accessible for repairs or alterations. Taps for these cables are run to balconies placed in each mill building in which are located a distribution switchboard and a transformer for transforming 220 to 110 volts for lighting. From the distribution panels, cables are again carried up to the roof trusses and through the length of the particular mill building in which the control balcony is located, from which taps to the various individual machines are made. These tap circuits are carried in conduits from a point level with the eaves of the building to the particular machine which is to be driven. Also, all circuits coming from the main feeder cable to the distribution panel in the balcony and back up to the individual mill circuits, are carried in conduit. In other words, conduit was used for all wiring below the level of the building eaves.

Each individual drive motor has a totally-enclosed circuit breaker located near it, thereby providing adequate protection to the feeders at the motor ends.

An interesting method of installing and wiring the general lighting in the mill buildings of this plant is used. Messenger cables were strung lengthwise on each side of the roof of the building and the lamps are suspended from the messengers. This allows the use of whatever spacing between them is desired. These messengers are hung from the roof trusses and hold the lamps above the cranes that pass beneath. The flexibility of the messenger wires provides whatever shock absorption might be necessary. The wiring for the lamps is carried

Spare sheet mill rolls are kept hot for emergency use.

The spare rolls are kept in the rack as shown. An electric roll heater is clamped around each pair of rolls as shown at each end of the rack. Power is kept on the heater continuously so as to keep the rolls ready for immediate use. This installation is in the plant of the International Nickel Co., Huntington, W. Va.



in open work on the roof trusses which makes the wiring very simple indeed. Access to the lamps for cleaning is obtained by standing on the bridge walkway of the cranes.

Improvements Made in Yard Transportation Systems

Ever since railroads have been used in steel mill yards as the backbone of the mill transportation system, the steam locomotive has been the accepted form of motive power. However, its wastefulness for switching service has long been recognized and many schemes have been used to overcome this wastefulness and high maintenance cost.

Many operators are showing considerable interest in yard electrification and some progress has been made. The Edgar Thompson Works of the Carnegie Steel Co. has recently purchased an 80-ton electric locomotive for moving hot metal from the blast furnaces to the mixer and steel plant. Power at 250 volts, d.c. is supplied by a double, third-rail system. Collectors are mounted at each of the four corners of the locomotive so that one or more will always be in contact with the third rails when passing over crossings, switches, and the like.

The Duquesne plant of the Carnegie Steel Co. is putting into service a 25-ton, storage-battery locomotive which is to be used by the Electrical Department in transferring motor armatures and other apparatus requiring shop repairs, to and from the electrical repair shop. Four storage-battery locomotives are used on the narrow gage railroad system in the plant of a large pipe manufacturer whose mill is located in the Chicago district.

Considerable interest has been expressed in the possibilities of the new oil-electric locomotives for industrial and steel plant switching service. Briefly, in these locomotives an internal-combustion oil engine, using low-grade fuel oil, drives an electric generator which furnishes power to electric motors geared to the axles of the driving wheels. The advantages are much more economical and speedier operation, and absence of noise and smoke. These locomotives are a joint development of the American Locomotive Co., Ingersoll-Rand Co., and General Electric Co.

In comparing steam and oil-electric locomotives for industrial and steel plant service, it is said that industrial plants are not generally equipped with shops and facilities for the convenient and economical repair of locomotives. In consequence, the maintenance of steam locomotives is higher than would be the cost of the same locomotives on steam railroads. In industrial plants the switching service is frequently intermittent, even more so than in large steam railway terminals. In all cases of intermittent service, it is a fact that the steam locomotive is using fuel during all of the period when the steam pressure is kept up. On the other hand, the oil-engine locomotive uses fuel only during the period when it is exerting power, and only in proportion to the power used. As a consequence, the more intermittent the service, the greater is the advantage of using an internal-combustion type of engine in the power plant.

Tendencies in Use of Electric Heat in Steel Mills

Developments in the use of electric heat in the steel industry are not at a standstill. On the contrary new applications and refinements in former applications are constantly being made.

Early last year there was installed at the plant of the International Nickel Co., Huntington, West Virginia, equipment for heating the tops of ingots, primarily Monel metal and nickel. Before using this equipment, 3,800 lb. of metal were poured to obtain a 3,000-lb. ingot, the waste averaging 20 to 30 per cent. Now 3,250 lb. of metal are poured and 85 per cent of the ingots are used with very little cropping, while a large proportion of the remaining 15 per cent is worked into commercial products.

Previous to the use of this method, it was necessary to cast the ingot with a head 18 in. long and weighing approximately 800 lb., the purpose of which was to take care of gas holes and pipes. Of course, it was necessary to saw off the head and return it to the furnace for melting. By the new method an electric arc applied to the top of the ingot keeps the metal at the top hot while the bottom and sides are cooling. The hot metal at the top is thus available to fill up any holes caused by shrinkage. Considerable success has attended the use of this method on Monel metal and nickel ingots and it may have possibilities on ferrous metal ingots.

Roll Heaters—The use of electric roll heaters in sheet mills is showing a large increase. Since September 1, 1925, 45 equipments have been sold. An interesting installation has been made at the Monel metal sheet mill of the International Nickel Co. With the methods of heating the rolls formerly used, it was necessary to roll steel sheets for more than one turn so as to get the mill warmed up and in proper condition to start rolling Monel sheets. This was required because Monel metal is too expensive a material to waste in getting the mill into condition for operation. It was, therefore, necessary to purchase steel bars and manufacture second-grade sheets in conditioning the mill. By using the roll heaters it is necessary to roll only two or three steel bars before going into production on the Monel metal sheets. The resultant saving is, therefore, considerable.

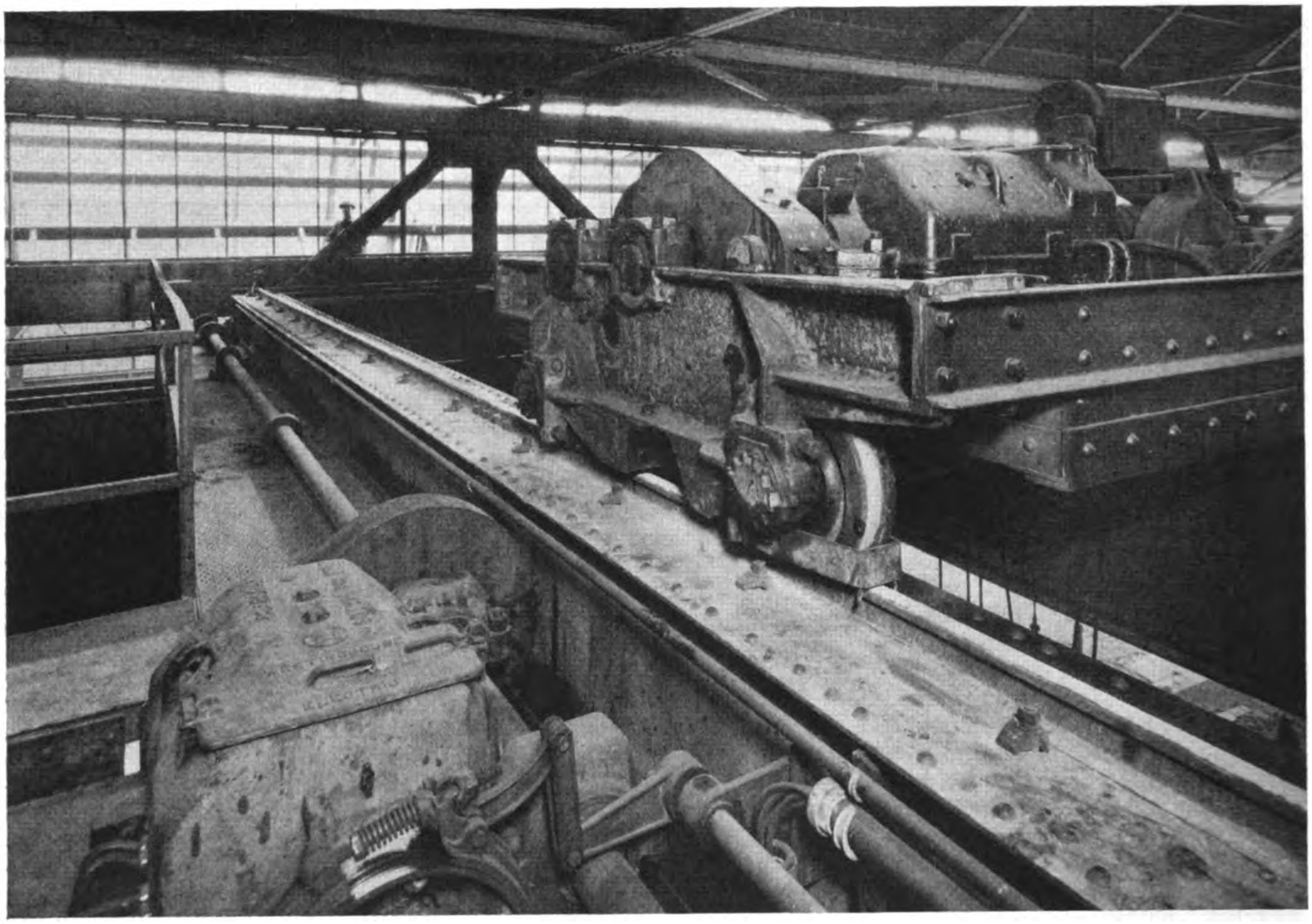
Some mills have fitted up racks to hold spare rolls in such a manner that a roll heater may be used to keep them hot and ready for immediate use in case it should be necessary to replace a set of rolls on account of breakage or wear. Such an installation is shown at the bottom of page 258.

Arc Furnaces—Installation is now being made of the first three-voltage control of arc melting furnaces. These equipments are to be used on 6-ton, three-electrode furnaces.

Each equipment consists of a 2,550-kva. bank of transformers which will deliver full output at 165, 156 or 147 volts and at lower capacity at 138, 120, 95, 90, 85, 80 or 70 volts. In operation the melter will have a choice of several voltages to start the heating, probably using 2,550 kva. at 165 or 156 volts, 2,400 kva. at 138 volts for the intermediate voltage and a still lower kva. at the refining voltage, probably 85 or 90 volts, depending upon the furnace requirements.

By using this equipment it is expected that considerable economies will be effected in furnace operation, especially from the standpoint of the life of the side walls and roof, together with possible reduction in electrode consumption.

In addition to these three equipments which were installed by the Halcomb Steel Co., four other equipments of this type have been sold, and it is expected that three-voltage operation will become the accepted method of operating arc furnaces taking 2,000 kva. and above.



This 15-ton crane is completely equipped with roller bearings.

It is one of a total of 32 cranes so equipped. Inspection will show the character of housings used to enclose the roller bearings on the lineshaft, motors, and hoist countershafts. Note the method of locking and enclosing the roller bearings on the trolley axles. All of these bearings are lubricated with grease and are filled through pressure fittings such as shown on the top of the bridge motor bearing in the left foreground.

Operating results obtained by use of

Anti-Friction Bearings on Steel Mill Motors

together with a discussion of the various factors that were considered in applying them to all bearings on thirty-two traveling cranes

By A. G. PLACE
Electrical Engineer, Youngstown Sheet & Tube Company, Youngstown, Ohio

IN THE manufacture of rolled steel products from iron ore, the product is never touched by human hands until it nears the finished stage. Throughout the manufacturing process it is handled entirely by machines which are universally driven by electric motors. These motors have to run 24 hr. per day, and delays on them must be eliminated. In our experience, the most valuable and interesting step in eliminating these delays has resulted from the use of roller bearings in these motors.

Early in 1918, our first successful roller bearing installation was made in the East Youngstown plant of the Youngstown Sheet & Tube Company by L. J. Hess, at the time chief electrician of the East Youngstown plant, and consisted of two sets of roller bearings in two mill-type motors on the bridge motion of a hot metal crane in a mixer building of a Bessemer plant. This is one of the worst locations in the mill for electrical equipment, because when hot iron from the blast furnaces is poured into the mixers, flakes of graphite and iron float in the air and cover everything in the building. These flakes are abrasive and also conduct electricity so that they are a prolific source of trouble.

The main reason for trying out these bearings was the possibility that roller bearings might eliminate bearing wear, bearing failures, and electrical failures due to oil penetrating the mica on the commutator and to oil on the windings. This trial installation was a marked success. Previously on this drive a 4-mos. run on babbitt bearings was considered to be very good, while frequent armature changes, broken bands, and flat spots on the commutator were the rule. When the roller bearings were installed, the armature was in poor shape and had an estimated life of 3 mos. if babbitt bearings were used. It ran on roller bearings for 9 mos. and after the armature was rewound and a new commutator installed, the motor has

run since then without further trouble.

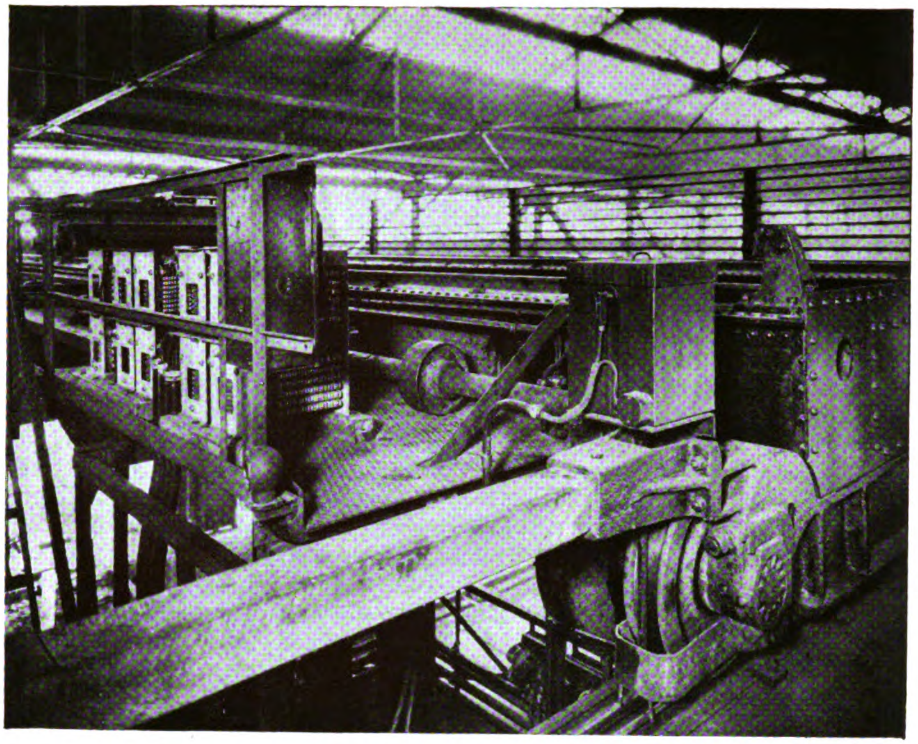
Excellent Results Obtained from Trial Installation

The excellent results obtained from this trial installation led to applications of roller bearings in other locations, such as reversing tables handling heavy ingots in the blooming mills, soaking pit cranes, screw-downs, and other locations where motors were hard to maintain. These first bearings were all applied to mill-type motors running at slow speeds, from 450 to 900 r.p.m., most of them having a pinion mounted on the armature shaft as shown in the illustration on page 262, although some drives were direct-connected.

The results obtained were exceptionally good. Oil was no longer deposited on the commutator and failures of the mica V-rings and segments decreased to a minimum. Failures due to oil-soaked windings were eliminated. With the armature always running in the center and with no low bearings, the field flux and air gap were uniform around the armature circumference. No trouble was experienced from grounds burning the roller bearings. It was no longer necessary to use "feelers" every Friday to determine what low bearings should be changed on Sunday.

The results obtained from the use of these roller bearings showed conclusively that maintenance costs can be substantially reduced, and consequently we have put large numbers of anti-friction bearings in service.

The first bearings were equipped with thrust plates, so that the end thrust would bear against rollers set in the plates, and all the shafts were heat treated. After the bearings had been in service for some little time, it was found that the thrust plates were not needed to take care of end thrust and hence they were omitted. Also, it was found that heat-treated shafts were unnecessary, and these have been abandoned.



Roller bearings are used in the axle bearings of the bridge.

The illustration shows the method of enclosing the roller bearings. The fitting for grease lubrication can also be seen on the side of the housing. Note the use of the electro-magnetic sander, shown in the right foreground, and also the crane warning lights in the left foreground. These warning lights are placed at the four corners of the crane.

Roller Bearing Installation Done Only in Shop

In order to make sure that the bearings would go into immediate service without any trouble, all installation work is done in the shop and each motor is given a 3-hr. test run at high speed before it leaves the shop. It has been found desirable to give the armatures sufficient

The lineshaft driving the bridge track wheels is also equipped with roller bearings.

This 15-ton crane is in the hot mill building of a sheet mill. It will be subjected to the usual severe steel mill service.

end play and accordingly the side clearances have been increased. Only one kind of grease is used in all roller bearings and care is taken not to fill the bearing too full of grease. A bearing about one-third full will run cool, but a full bearing will heat up. In determining the sizes of bearings that should be employed on a given application, we have used a large enough factor of safety with the result that no failures have occurred from using sizes too light for the duty required. The bearings used have consequently given satisfactory service.

The satisfactory results obtained have proved that inspection labor can be cut down materially in addition to the savings resulting from the following items:

(1) Reduced number of rewinds caused by oil-soaked armatures.

(2) Reduced lubricating expense.

(3) Reduced repair and shop labor on bearing renewals.

(4) Less oil and grease on rolled products.

(5) Less power consumption.

(6) Reduced inventory of spare commutators and coils.

After calculating the above savings, it was determined that a substantial return exists on the investment cost required to equip all new motors with roller bearings. This added investment cost is approximately ten per cent extra per motor. Accordingly, practically all new motors have been purchased with roller bearings.

Roller bearings have been used in our plants in other application than on electric motors. Ingot cars and coal mine cars have been so equipped for several years. As a result of the service obtained, the management decided to equip completely 32 electric overhead traveling cranes with roller bearings throughout. The illustration on page 261 shows the general type of cranes on which the roller bearings are installed.

In applying these bearings, a great deal of attention in co-operation with the crane builders was paid to the following details:

The bearings on the trolley side frames are enclosed in housings and the housings in turn have a spherical seat in the trolley frame casting, in order to prevent strain on the bearings when the trolley loosens up after continued service. This may not prove necessary but was adopted after tests and observations on present heavy-duty crane trolleys. End thrust on the bearings was allowed for in all cases.

The roller bearing diameter on the bridge lineshafts had to be in English inches instead of in the metric dimensions of the recently adopted standard for roller bearings, in order to permit the use of cold-rolled shafting on the long lineshafting, which is made up in diameters based on the English system of measurement.

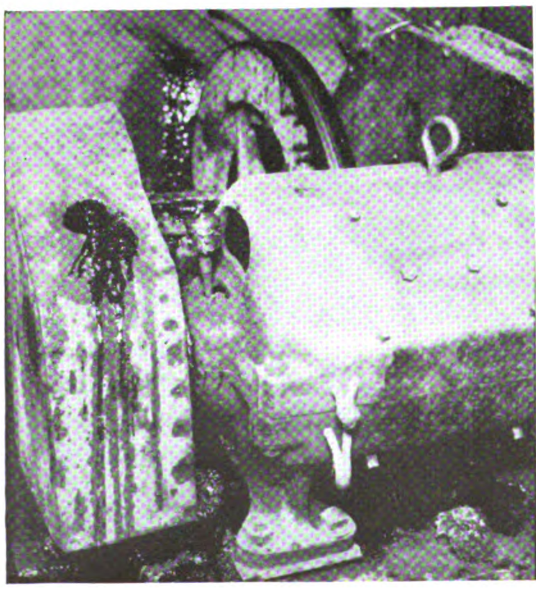
The back or axle shaft bearings on the motors are equipped with roller bearings, each incased in a housing which is carried mounted on the shaft. These housings are advisable in order to keep the dirt and steel dust out of the bearings in case a shaft has to be changed. A spare shaft can be carried with the housings and bearings already mounted.

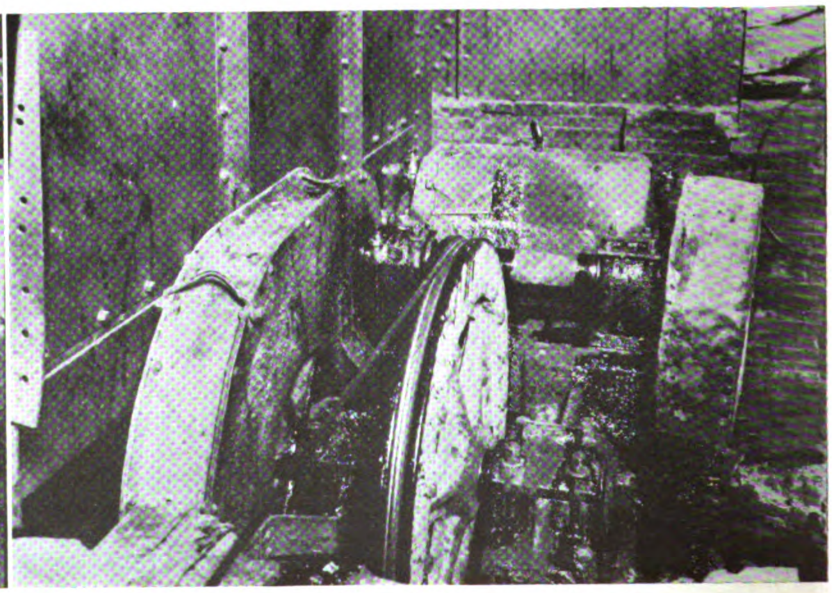
The sheaves on the hook blocks are equipped with roller bearings on some cranes, but not on all. The large pin diameters on blocks of over 15 tons capacity make it necessary to use such large diameter roller bearings that the cost runs up beyond the economical point on these particular bearings.

Most of the cranes have just been erected and started up, hence it is too soon to make any statement regarding the operating results.

There are other applications in steel mills where it may be possible to secure savings by using roller bearings and several such applications are now being investigated. In applying roller bearings to any steel mill work there are two important factors that must be given considerations: (1) Whether or not it is possible to make a saving sufficient to justify the extra investment required; and (2) whether or not the machinery can be designed with roller bearings and be absolutely correct in design so that it can be depended on for continuous operation.

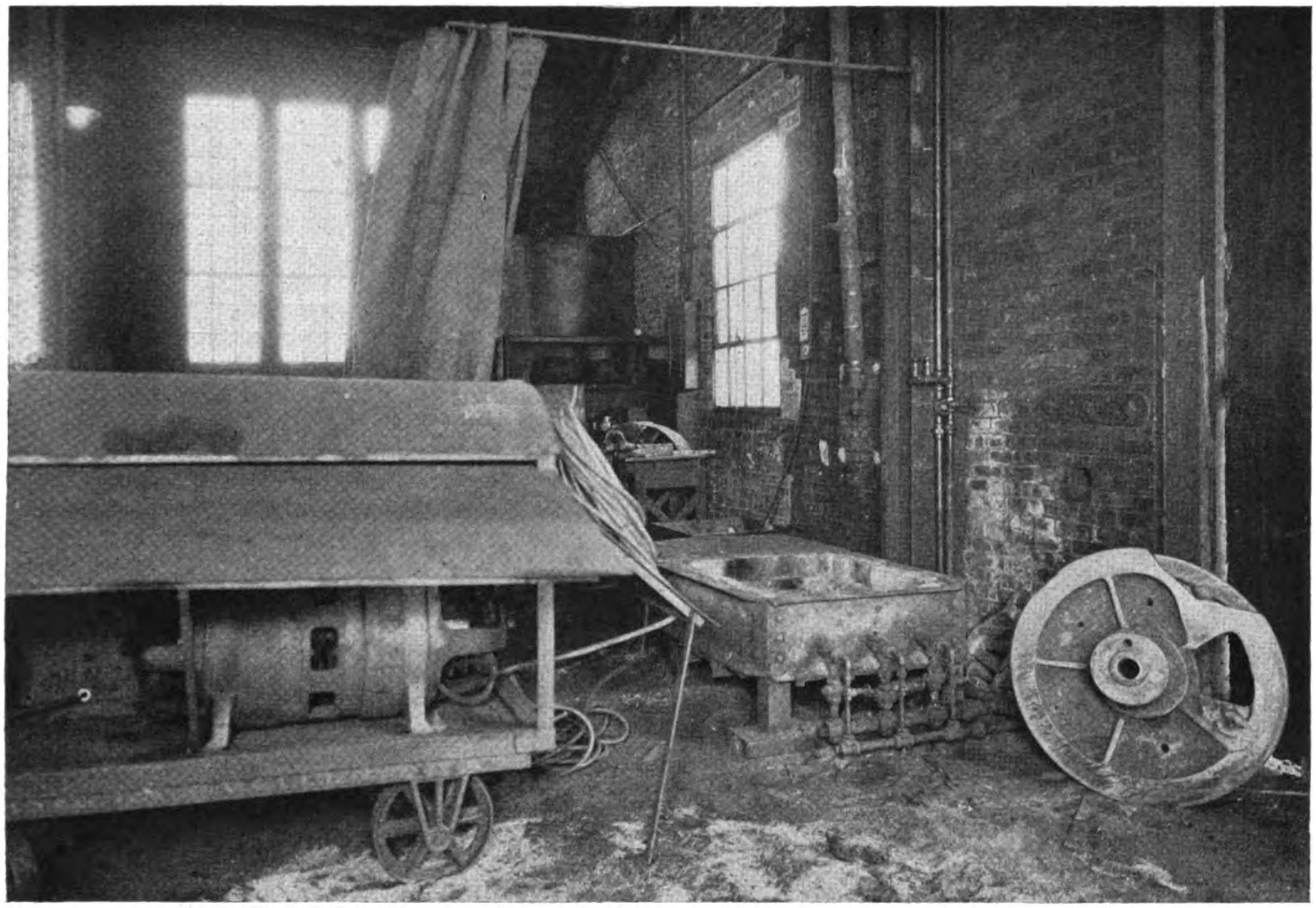
In general, it may be said that we have found anti-friction bearings on electric motors to be a remarkably good investment. It is not at all surprising that this is the case, when it is considered that motors are very expensive, and that for 10 per cent additional cost they can be insured against failures which require expensive repairs.





The motor shown in this application has roller bearings on its armature shaft.

The illustration at the right gives some idea of the service conditions under which the motor operates. The drive is located in a pit at one end of the blooming mill soaking pits. The motor drives a sheave wheel through two gear reductions, which pulls a cable that draws an ingot buggy carrying ingots from the soaking pits to the mill approach table. The drive is subjected to plugging and sometimes to "inching" the buggy for spotting.



When not required outside the arc welder unit is kept near the curtained enclosure.

This is a portable, 300-amp. Lincoln arc welder. It is plugged into the receptacle on the wall through a 150-ft. Tirex extra-heavy rubber cord. The 150-ft. cord is long enough so that welding may be done almost anywhere in the shop without moving the machine. The welding bench and cabinet are shown in the background. The preheating furnace is connected up with gas and air lines and is used for all castings which must be preheated before welding. The large cast sheave wheel at the right belongs to a clamshell bucket, and was brought to the shop to have the broken sheave welded.

Some applications of

Arc Welding in Plant Maintenance Work

including the procedure followed and the savings in time and money that have resulted from the use of this process in repair and new construction work

By F. A. HAGEDORN
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WHEN we added an electric arc welding unit to the equipment of the Maintenance Department some doubt existed as to whether there would be enough work to keep it busy and make it earn on the investment. Now we are wondering how we ever got along without it.

The South Chicago plant of the By-Products Coke Corporation covers 110 acres, contains 330 ovens, a coal unloading dock, several miles of conveyor systems, a power plant, and numerous tanks, pipe lines, and other equipment necessary in the processes we employ. The manufacture of coke and gas is a continuous process and the plant does not stop even for holidays.

Because continuous operation is of such prime importance it is essential that we maintain every possible facility for making the repairs or alterations necessary to keep the plant going. On the other hand, the hot gases and liquors, as well as the abrasive coal and coke dust, are most destructive to the plant equipment. This necessitates a large amount of renewal of broken and worn parts of the equipment or structure. We are using our acetylene and arc welding units together on this work, and every day are finding new uses for them. At present, whenever a large or small repair or construction job becomes necessary, practically the first consideration is to see whether a welding or cutting set can be used in the work.

The acetylene outfit had been in the plant for several years before we installed the arc welder. At present we have 11 Oxweld (Oxweld Acetylene Company, New York, N. Y.) sets for maintenance work. All sets are portable and consist of an oxygen and an acetylene cylinder mounted on a hand truck with a torch and gas and air hose. These sets are

Three other examples of construction work made in the shop.

The sections of pipe on the bench are to be part of a return bend. The bent angle-iron frames on the bench are used to bolt the sections together while arc-welding. These sections were cut out of old pipe with the torch. The shop horse and the portable forge are other examples of arc-welding jobs.

taken anywhere in the plant as necessary.

The arc welder is a 300-amp., type FKW-FKW Lincoln (Lincoln Electric Company, Cleveland, Ohio) portable, motor-generator set. Receptacles are located at many places around the plant to tap this outfit into the 250-volt, direct-current distribution system. Frequently it is necessary to take the set outdoors. One of the first things we did was to build a steel housing over the set to protect it from the weather. On one of our first big welding repair jobs the arc welder remained outside for three or four weeks.

All connections to the arc welder are made with Tirex (Simplex Wire & Cable Company, Boston, Mass.) heavy rubber portable cord. There are 150 ft. of this cord connecting the welder to the electrode holder, 75 ft. to the ground, and 50 ft. from the receptacle to the machine.

Our basis of dividing the work between the arc and acetylene outfits may be interesting to others. Cast iron and all jobs which require preheating are welded with an acetylene outfit; also, a considerable amount of cutting is done, as will be described later. In addition, many of the smaller welding jobs which cannot easily be brought into the shop are acetylene-welded because the portable gas units are smaller and more easily moved.

Practically all steel welding, except the small jobs which are done around the plant without dismantling the equipment, is performed by the arc unit. In some cases both gas and electric outfits are used.

We have one experienced man capable of performing any necessary welding with either the gas or arc units, and another who is breaking in and can do many of the simpler jobs.

In all of our welding or repair work we keep two primary considerations in mind: the welds must be substantial and the work must interfere as little as possible with the continuous operation of the plant. Appearance of the weld is not in our case so important as it is in some other industries; however, the welder takes enough pride to do neat work. Also, we do not sacrifice reliability to save a little in time or material.

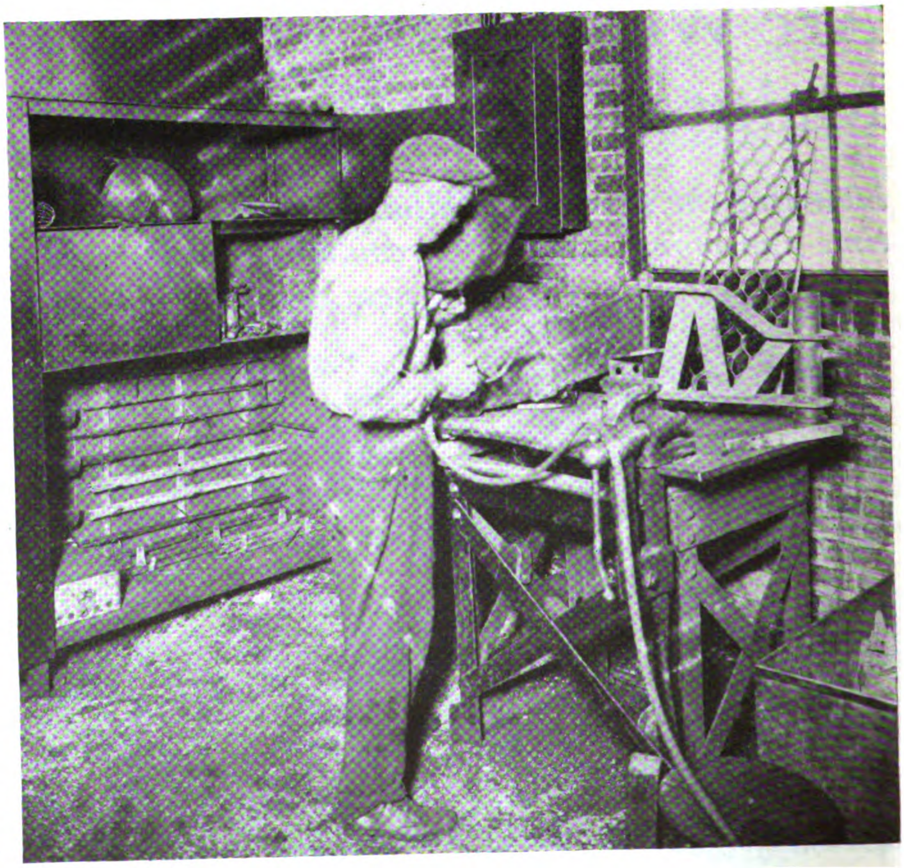
Two large welding jobs stand out above the others so prominently because of their size and importance that they deserve first mention. One of these consisted of about 400 ft. of heavy welding on a gas collector main, and the other was the construction of a large seal.

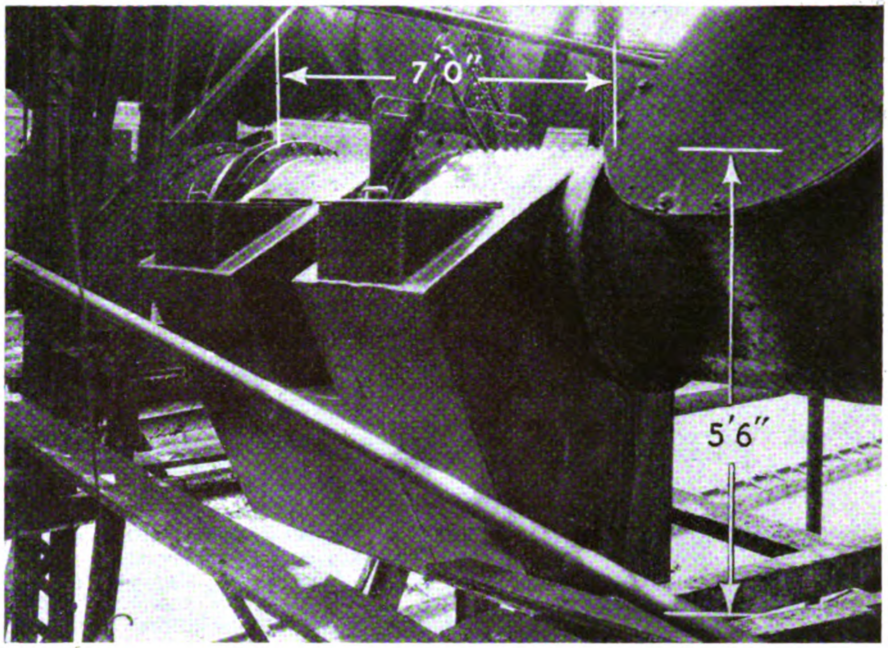
The hot gas and liquors in the gas collector main, which extends across the top of each battery of 40 ovens, corrode the baffle plates which dip down into the liquor and make a seal. These plates have to be renewed periodically. The former method consisted in stopping coke-making on the entire battery of 40 ovens, and then cutting out the old rivets and riveting in a new plate. This work was pushed as rapidly as possible, but usually required about 10 days. The loss of 10 days' production every five or six years is a big item of expense and amounted to more than the cost of the repair.

Shortly after installing the arc welder we conceived the idea of replacing the baffle plate by welding, and without stopping the operation of the ovens. How this was done is best shown by reference to the illustration on page 265. The row of rivets just above the arrow indicates the previous method of fastening the baffle plate which can be seen through the open inspection door. The metal doors and the framework covering the trough were corroded so badly that they had to be replaced

This shows the welding bench and cabinet, with examples of work done.

This bench and supply cabinet are enclosed with a heavy canvas curtain. The welder has just finished building up a large gear guard by welding steel plates together. The floor grating leaning against the window was arc-welded together by one man in less than half the time that would be required by two men to rivet it. The other piece on the bench is a special replacement part.





This large seal is a good example of the type of work on which welding may be used.

This seal is made from two pieces of 30-in. heavy riveted pipe, four flanges cut out of 1-in. plate and welded on, and a box welded from $\frac{3}{8}$-in. plate. On the inside of each end of the seal, pieces of 12-in. pipe are welded onto the lower side of the 30-in. pipe and extend down almost to the bottom of the seal. A steel plate between the flanges closes the 30-in. pipe in the center to prevent gas passing. The liquors are forced down into one side of the seal, up the other side, and withdrawn. The flanges and pipe were all cut with the acetylene torch and arc-welded together.

also. New covers were made up, the old metal cut out, and the new parts welded in position. The weld is indicated by the heavy deposit of metal which serves as a fillet to bind the new cover plate to the gas collector main. The old baffle plate was then cut off and the new one bolted on, as shown by the row of bolts just below the arrow, in the illustration below.

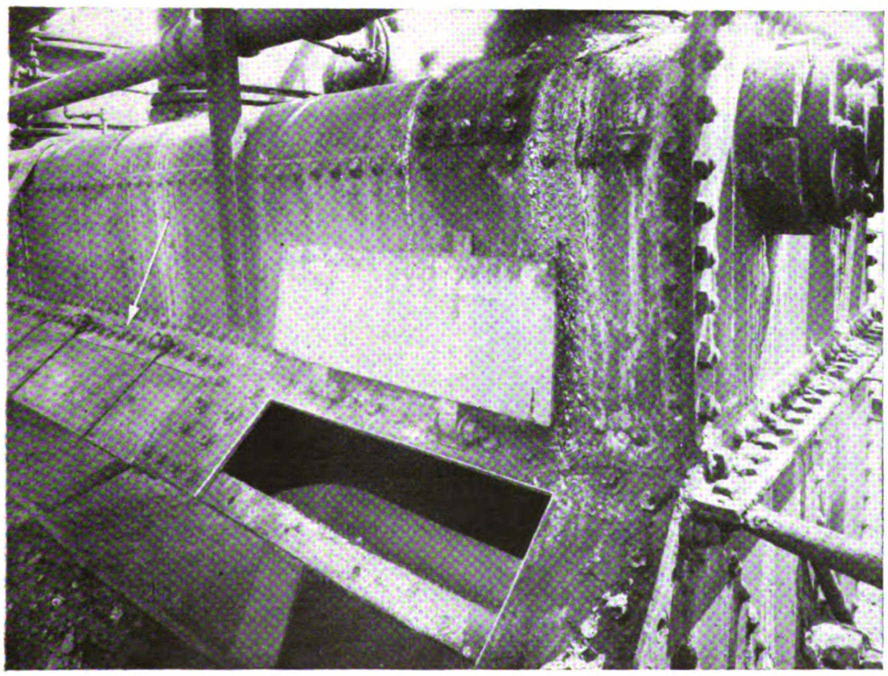
This work was done in sections and required between three and four weeks. However, the battery of ovens was in continuous operation all the time. The gas in this collector main is under very low pressure. While the work was carried on a man was stationed at a regulating valve to keep the pressure as low as possible. Pails of sand were kept within reach to smother out the few fires that were started by the welding or cutting units.

This repair was made a year ago and is standing up very well. A big advantage, in addition to not having to stop the operation of the ovens, is that the next time the baffle plates have to be changed it can be done by taking out the row of bolts and fastening on a new plate. If any part of the wall corrodes, either the surface can be built up or another piece of metal may be tack-welded down over it. In our opinion the new arrangement is much better than the old. The comparative costs of labor and material in making this repair in the old and new ways are in the ratio of about 4 to 1. This comparison does not take into account the big advantage of being able to operate the ovens while making the repair.

The gas collector main on a second battery of 40 ovens was welded in a similar manner shortly afterward. These two jobs totaled about 400 ft.

The other large welding job was performed on the seal box shown in the illustration on this page. This has just been completed and placed in position. This box was made up completely by cutting and welding and had to be of exact length to fit into the section of the line which it replaced.

This seal consists of two pieces of 30-in. steel pipe each about 42 in. long. These were cut to length with the torch. The four flanges were cut from 1-in. steel plate with the torch and arc-welded on. The alignment of the bolt holes had to be perfect. A piece of sheet steel fits in between the center pair of flanges and prevents the passage of the gas. The liquors enter from one end and pass down into the seal through a 12-in. opening and pipe extending down into the seal, and on out through a similar opening and pipe extension in the other end of the



This and a companion job required 400 ft. of arc welding.

This is the seal on the gas collector main; it is mounted above and extends the entire length of a battery of 40 ovens, a distance of about 200 ft. Formerly it was necessary every five or six years to stop coke-making for about 10 days to replace the corroded baffle plates, which extend several inches down into the liquors. The baffle, which may be seen through the open door, was formerly riveted on; the longitudinal row of rivets holding this is shown beside the arrow. About a year ago entire new covers and doors to the seal were welded on at the seam indicated by the arrow. The new baffle plates are bolted onto this cover as indicated by the row of bolts and can be replaced or tightened up at any time. Four or five men did the necessary welding, without interfering with the operation of the ovens, and at one-sixth the former cost for labor and material.

seal. Thus the liquors pass on and the gas is retained. This box part of the seal was made up from steel plates arc-welded together. The straight edges of the 3/8-in. steel plate forming the box were sheared true. The curved saddle fitting onto the 30-in. pipe was cut out with the torch. The plates in the seal were welded up in the shop in two days. The cutting and welding of the pipe sections took longer.

The cost was considerably lower, I believe, than would have been the case with any other way of making this seal. We expect to make others as necessary. Corroded plates may be repaired by building up metal on the outside or by tack-welding a plate over the thin metal.

Arc welding requires clean metal and a clean surface, neither of which are provided for in most of the necessary repairs around a coke plant. Frequently we use the acetylene torch to clean up the metal, and then weld on a patch with the arc.

Another large job which represented not only a considerable saving in money but, what was more important, reduced the time out of service from several weeks to a few days, was the welding of the manganese-steel bowl shoe or biter strap on a 6-ton clamshell coal bucket. This was broken in several places and a new shoe would have cost about $500, while several weeks would have been required for delivery. Upon hearing this from the manufacturer we decided to try arc welding. Manganese-steel welding rods were used and the bucket was soon back in service. Estimating $15 or $20, which are ample figures, as the cost of the welding, the saving on this job totaled $480 or more. The cost of the freight on a new shoe and the loss caused by the bucket being out of service for the several weeks would probably have amounted to as much more.

While these three jobs may be considered as the high lights of our experience in welding they actually represent only a small part of the work. Much of the welding consists of miscellaneous little jobs some of which represent repair or broken parts; others are new construction.

It is, of course, almost impossible to list the welding jobs handled in any given time. A few representative jobs, however, are of interest.

Most of the motors in the plant are connected up through gear drives. The heavy shock loads, such as starting conveyors and other heavy equipment, loosen up the keyways in the shaft. In such cases, the old, worn keyway is filled in by arc welding, the ridge of surplus metal turned down in a lathe, and a new keyway cut in the shaft. This makes it practically as good as new and the operation may be repeated whenever necessary. During the course of a year we salvage a number of motor shafts by welding in this way.

Also, we frequently find it necessary to build up the diameter of a shaft by arc welding. In another case a 30-in. cast-steel gear with a 5-in. face was salvaged by arc welding in a few new teeth. A new gear would have cost $100 or more.

We use a considerable amount of steel floor grating. As changes are made in the plant gratings of special sizes or shapes are required. To get these quickly, we purchase the steel straps already bent and punched and formerly had been riveting or bolting these together as necessary. Now the bent straps are assembled and clamped together in position and arc-welded on both sides. Welding requires less than half the time formerly taken by two men to rivet or bolt the strap together. One man alone can weld them.

Much of the new structural work about the plant is being arc-welded as it is quicker and cheaper, we believe, than riveting. Practically all old structural work is cut out with a torch. So far, however, we have not tried welding up any pipe lines.

Due to the abrasive action of the coal or coke dust the steel conveyor pulleys wear rapidly. These are repaired in the shop by bending a new steel plate around them and welding up the seam and ends.

Another job of considerable size consisted in cutting the feed pipes between the bunkers and the stokers in our power plant and rewelding them at a different angle. The cutting and trimming were done with the gas torch and the welding by the electric arc.

(*Please turn to page 271*)

Quantities of Electrodes Used Monthly

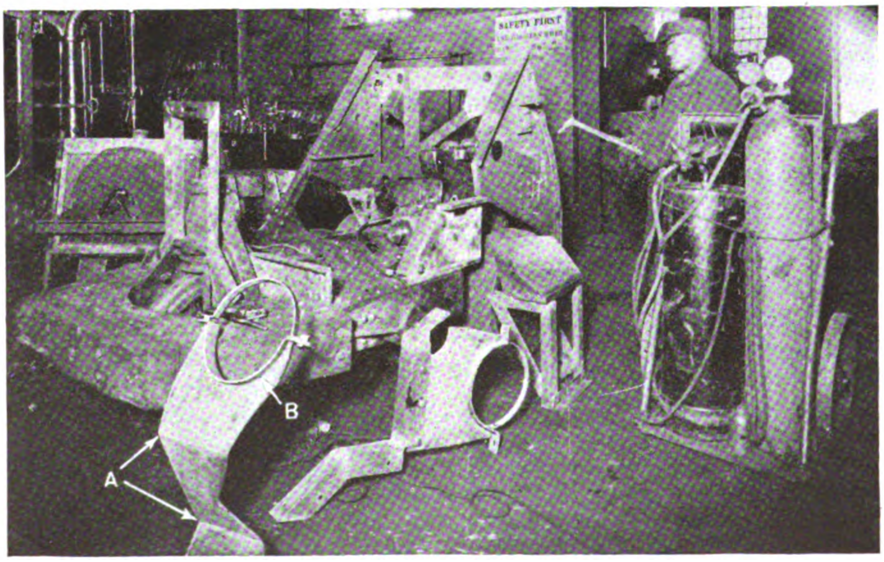
100 lb. 1/8-in. Arc Carbox
50 lb. 5/32-in. Arc Carbox
50 lb. 3/16-in. Arc Carbox
(Central Steel & Wire Co., Chicago, Ill.)

25 lb. 3/16-in. iron rod
50 lb. 1/4-in. iron rod
10 lb. 1/8-in. iron rod
10 lb. 1/8-in. steel rod
10 lb. 1/4-in. cast-iron rod
(Oxweld-Actylene Co., New York, N. Y.)

10 lb. E-Z Welding Compound
(Anti-Borax Compound Co., Fort Wayne, Ind.)

Miscellaneous Supplies Used in Small Quantities

1/8-in. Nickel steel
3/16-in. Nickel steel
1/4-in. Nickel steel
1/4-in. Manganese steel
3/16-in. Lynite aluminum
1/4-in. Lynite aluminum
1/8-in. Tobin bronze



Both gas and electric units are often used on a repair job.

A large proportion of the metal cutting is done with the gas torch. Most of the steel is welded with the arc. This illustration shows one of the portable gas sets. This special gasoline industrial truck is being rebuilt, largely by cutting it apart with the torch and then welding in new parts. The bends indicated at *A* were made by cutting a slot through the metal (except for about 3/8 in. at each edge) where the bend was to be made. After making the bend cold the slot was filled in with the arc. The collar *B* was made from a curved steel strap, arc-welded on. The other pieces on the floor were also cut to shape with the torch and arc-welded.

Operating Characteristics of Crossed-Belt Drives

as determined by a series of tests, with particular reference to the minimum center distances which can be used in laying out such drives

By R. F. JONES
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IN THE study of the characteristics of belt drives under various operating conditions, The Leather Belting Exchange Foundation has been conducting tests on leather belts under different services. Previous tests have been made and reported on horizontal belt drives to determine the effect of diameter and ratio of pulleys, center distance, high belt speed and the use of the gravity idler. The results obtained were published* in the June, 1925, issue of INDUSTRIAL ENGINEER in the form of curves and tables that gave the power which belts of various weights are able to transmit at different speeds, with the correction factors which indicate the necessary allowances to be made when laying out the types of drives mentioned above.

Another article* in the April, 1926, issue of INDUSTRIAL ENGINEER contained added information and data on the relative power transmitting capacities of horizontal and angular leather belt drives. The method of applying the data obtained in the second of this series of tests with the data which appeared in the first article is also explained.

Additional studies have been made recently upon crossed belt drives to determine the characteristics of the drive and, if possible, indicate methods of utilizing this resultant information in establishing methods of laying out such drives.

The 100-hp., laboratory belt-testing apparatus of The Leather Belting Exchange Foundation was used for this work. As this equipment has been described in previous articles no description is necessary here except to point out that the equipment readily lends itself without changes to crossed belt tests because either the driving or driven unit may be run in either direction. Measurements of the torque, revolutions per minute, belt slip, total tension on both strands of the belt, arc of contact on either pulley, and center distance may be taken with this apparatus.

The present experimental work naturally divided itself into two parts. First, transmission tests to determine the power transmitting capacity of crossed belts compared with normal belts; and, second, experiments using various combinations of pulleys, at various center distances, to find out how these factors affect the operation of crossed belts. A common trouble with crossed belts is running off the pulley when under load, which is often prevented by mechanical means such as a shifter fork. This practice is obviously detrimental to the belt. Therefore, the principal object of the second part of these tests was to determine the limiting conditions of pulley diameter and center distance which, if exceeded, would cause the belt to run off.

The experiments were started with two 6-in. belts, Nos. 1 and 2, the former having a buffed grain surface for low-capacity work, and the latter, a normal, high-capacity grain surface. Later other tests were made on two 4-in. belts, No. 3, a light double and No. 4, a heavy double belt, both of which had a normal grain surface. The double belts had been used in other experiments, and therefore required little running in. The dimensions of these four belts are given in Table I.

Belt No. 1 was carefully run in until it gave promise of giving uniform results. Capacity tests were then made on standard 24-in. pulleys at 3,000 f.p.m. to compare the crossed and the normal open drive. A buffed belt was used because a more constant frictional condition can be maintained with this type of belt surface. After making a few experiments to determine some of the characteristics of the crossed drive, another comparison between the two drives was made, using a 9-in. driver and a 36-in. driven pulley at a belt speed of 2,000 f.p.m. In each case the direction of rotation was chosen so as to bring the tight side of the crossed belt onto the bottom of the driver pulley, resulting in greater wrap on this pulley. The tests on the 24-in. pulleys were run at approximately 15-ft. center distances, and those on the 9-in. to 36-in. combination were run at about 10-ft. centers. The results of this test are given in Fig. 1.

At this point the first series of experiments was begun to determine the limitations of the crossed drive. Trials were first made on different combinations of pulleys at three center distances, using the tight side of the belt below and also above the driver pulley; each pulley was tried as the driver when the two were of different sizes. The 6-in. belt was then cut lengthwise into a 2-in. and a 4-in. belt and the complete series of experiments was repeated on these widths. The load was gradually applied to each drive until full load was reached, or until the belt ran over the edges of the pulleys. If the drive carried full load successfully, further load was applied until the belt slipped badly or ran to the edges of the pulleys.

A tension of 175 to 200 lb. per sq.in., which is about average prac-

Table I—Specifications of Four Belts Tested

Belt	Weight	Original Width, In.	Thickness, In.	Original Length, Ft.	In.	Weight Oz., Sq.Ft.	Remarks
No. 1	Single	5.96	0.205	36	3/16	15.3	Grain buffed
No. 2	Single	6.15	0.21	35	9¾	17	Normal grain
No. 3	Light double	4.01	0.30	29	11	23.6	Normal grain
No. 4	Heavy double	3.96	0.422	29	10⅝	32.3	Normal grain

*Readers who do not have copies of the June, 1925, and April, 1926, issues of INDUSTRIAL ENGINEER on file may obtain the information on which these previous articles by Mr. Jones were based by requesting Reports R-13 and R-14 from The Leather Belting Exchange, 417 Forrest Building, Philadelphia, Pa.

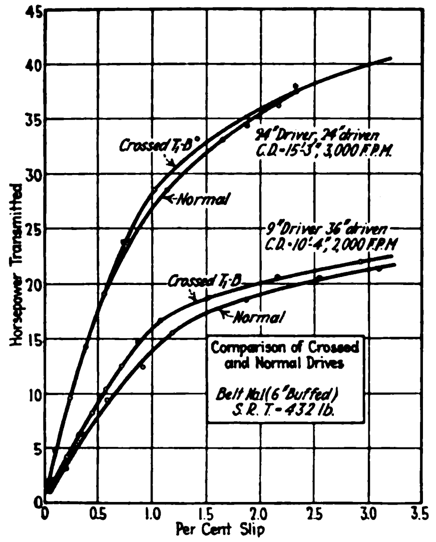


Fig. 1—In these tests the crossed belt transmitted more power than a belt on a normal horizontal drive.

This was probably due to using a buffed belt which did not seem to be affected as much by the rubbing of the belt at the cross as were the standard belts.

tice, was used for all belts. We found after some experiment that tensions higher than this made the belt stay on better, while the reverse was true if the tensions were lower. The belt speed did not seem to have much effect, except that the belt would run off faster at higher speeds once it started. Therefore, no attempt was made to keep the belt speed absolutely constant with the different pulley combinations, although it was generally near 2,000 f.p.m.

Most of the crossed drives fall into two classes: namely, drives where the belt runs to the edge of the pulley at light loads, and those which will carry full load or more without the belt running much off the crown of the pulleys. Practically all crossed belts will run off if they are slipped much above normal. A few, where a very small pulley is used as the driver, will run off one edge of the pulley at no load, and will work over as the load is applied, and tend to run off the opposite edge at overloads. Or, if the large pulley of such a combination is driving, the belt will run off the edge of the small pulley at no load, and will go further off if any load is applied. No drive was considered entirely successful unless the belt would carry full load and stay within 1 in. of the same position on the pulleys while the load was brought to this value.

After belt No. 1 had been reduced to 4 in. in width, transmission tests were made on the 9-in. to 36-in. pulley drive at 10-ft. centers, and 2,000 f.p.m., with the tight side coming on the driver both from below and from above, to determine how much difference, if any, this made. A normal drive test was made at the same time for comparison. The experiments on belt No. 1 gave us the experience necessary to make more thorough and systematic tests on the other belts. The data obtained by testing the 4-in. belt are plotted on the curves in Fig. 2.

Tests were continued on belt No. 2, the 6-in. belt with a normal grain surface, under practically all possible combinations of our laboratory stock of pulleys; these ranged from 4, 6, 9, 12, 18, 24 to 36 in. in diameter. Center distances ranging from 5 to 17 ft. were used. The original 6-in. belt was then cut into a 4-in. and a 2-in. belt and the experiments repeated on these widths.

Transmission tests on the 2-in. width of belt No. 2 at 10 ft. 7 in.-center distance, were made on the 9-

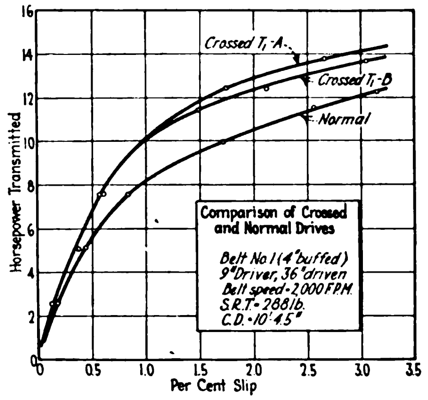


Fig. 2—Here the crossed belts transmitted about 20 per cent more load than the normal belt.

Even though the crossed belt may show higher power-transmitting ability than a normal drive under test conditions it should never be rated higher because the crossed belt is very sensitive to excessive load and slippage and to a decrease in tension.

to 36-in. drive to compare normal and crossed drives, with a high-capacity belt. We had previously noticed that the high-capacity belts did not seem to do as well when crossed and the results of the tests, given in Fig. 3, show this very clearly. These crossed-drive curves stop at about 2.25 per cent slip because the belt threatened to run off at this slip.

Similar experiments were run on the light and heavy double belts, Nos. 3 and 4. These belts were shorter than the singles and, therefore, the various pulley combinations were tried at two center distances instead of three. As we had found in our tests on the single belts that the three widths acted about the same, the tests on the doubles were confined to the original 4-in. belt.

A study of the results obtained up to that time revealed that some of the data were confusing and contradictory, especially on the single belts. Further experiments indicated that the direction of the cross seriously affected the results on the 2-in. belts, and to a lesser extent those on the 4-in. belts. For example, a belt which would not carry more than half-load crossed one way, without running off, might carry full load, or more, if crossed the other way. After this fact was determined all doubtful drives were checked over again with the belt crossed both ways.

Considering first the results of the transmission tests, the horsepower-slip curves of which are plotted in Figs. 1, 2 and 3, the crossed drive gave slightly higher power transmission than the normal drive in the case of the belt with a buffed grain surface, Figs. 1 and 2, while with the belt having a normal grain surface, Fig. 3, the reverse was true. For instance, in Fig. 1 we found that the 24-in. to 24-in. crossed drive at 1½ per cent slip transmitted 3 per cent more power and the 9-in. to 36-in. crossed drive at the same slip transmitted 7½ per cent more power. With the same belt after it had been cut to 4-in. width, the difference between the two curves at 1½ per cent slip, as shown in Fig. 2, is 20 per cent.

The opposite result, indicated in Fig. 3, is probably due to a lowering of the co-efficient of friction caused by the rubbing at the cross. This effect was noticeable every time the high-capacity belts were crossed, because a little running in with these belts on a normal drive would

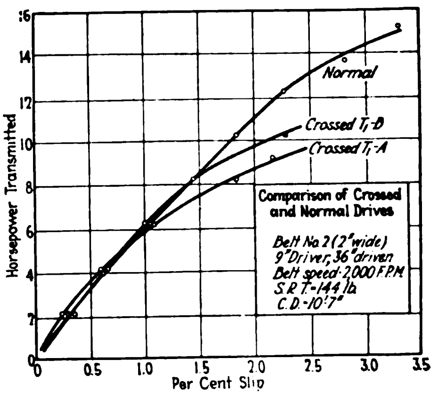


Fig. 3—These tests were run on a high-capacity belt.

In this case, which approximates normal operating conditions, the normal horizontal drive transmitted the heavier load. A 9-in. pulley drives a 36-in. pulley on 10 ft. 7-in. centers.

bring up their capacity, and it would drop off again when they were put on the crossed drive.

It is likely that the buffed surface was not subjected to this action, so that the difference between the two drives, as indicated in Figs. 1 and 2, is more nearly correct. Although the transmitting capacity of the crossed drive was slightly superior to the normal drive, averaging about 10 per cent for the three comparisons, the crossed drive is, under most conditions, very sensitive to excessive load and slippage and, therefore, it should not be rated higher than the normal drive.

The difference in the power obtained in the two cases, where the tight side of the belt is below and above the driver pulley, is small. In one case the tight side above transmitted more power, while in the other case the tight side below transmitted more power. Evidently there is little to choose between the two conditions, so far as power transmission is concerned.

A clearer understanding of the meaning of the terms "tight side below" $(T_1\text{-}B)$ and "tight side above" $(T_1\text{-}A)$ may be obtained from Fig. 4, a line drawing of a crossed belt drive. The arrows at the driver pulley indicate which way this pulley must turn for tight side to be above or below.

A few general conclusions, dealing principally with the ability of crossed belts to stay on the pulleys at full load, were made from a study of the data obtained. They are as follows: First, there is a minimum center distance for every combination of pulleys, below which a belt under average tension will not carry full load without giving trouble, although it may carry some portion of its load. Second, belts in widths ranging between 2 in. and 6 in. behave in about the same manner, for most of the pulley combinations, and have approximately the same minimum center distance, with a few exceptions. Third, the ability of a belt to operate well on a crossed drive partly depends upon the amount of initial tension used, and belts under high tension will work at shorter center distances than those under low tension. Fourth, belt speeds up to 5,000 f.p.m. have little effect on crossed belt operation, except that due to the usual reduction of capacity caused by centrifugal force. Fifth, double belts act approximately the same as singles, but they tend to stay on the pulley a little better; thus in some cases they can be operated at shorter center distances. Sixth, a small pulley driving a large one is a more stable drive than a large pulley driving a small one and gives a drive which can be operated on shorter centers.

For practical use the operating data have been condensed into Table II, which is divided into two sections, one for single belts and the other for double belts, which give the minimum center distances at which the various crossed drives will carry full load without a troublesome tendency on the part of the belt to run off. The driver pulley diameters are placed horizontally across the top, and the driven pulley diameters are given vertically on the left edge. The letters *B* and *A* in the vertical columns indicate whether the tight side of the belt should be below or above the driver pulley as the belt comes on it. The intersection of the vertical *B* or *A* column under the driven pulley diameter with the horizontal column opposite gives the minimum center distance in feet for the drive. Several references in the single belt table are used to indicate different center distances for certain widths. Small *c* means that the value given could not be determined experimentally, and was therefore calculated or estimated. In a few cases where the data did not warrant an estimate, no value is given. It should be especially emphasized that in case the belt does not work well at or above the center distance given, the cross should be reversed.

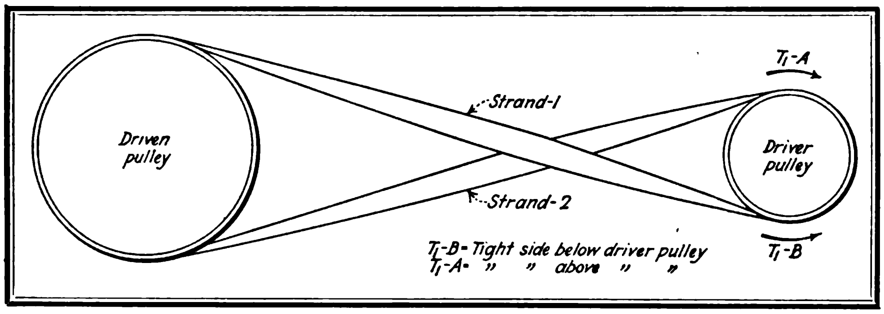


Fig. 4—The arrows show the direction of rotation with the tight side of the belt above and below.

More stable operation of a crossed-belt drive results when a small pulley is driving a large one. Frequently when a crossed belt continually runs off the pulley the difficulty may be remedied by crossing the belt in the other direction. This does not mean, however, to twist the belt so that the grain side is the driving side against one pulley and the flesh side against the other pulley.

Most of the drives within the range of these tables will carry light loads well at a center distance 25 per cent less than is given here, but for full load these drives would probably require some mechanical means of holding on the belts, such as a shifter fork. Results of the tests would indicate that it is not advisable to use for any drive center distances less than 75 per cent of those indicated in the tables. It seems that there is no practical upper limit of center distance, although at long distances the belt might begin to flop, which would cause the drive to be unstable.

The drives within the range of the experiments thus naturally fall into three classes:

(1) Those using center distances as great or greater than indicated in the tables, which can be expected to transmit full load, but not overloads.

(2) Those using center distances between 75 per cent and 100 per cent of the table value, which will carry light loads, but probably not full load without mechanical help to keep the belt on.

(3) Drives at center distances less than 75 per cent of the table value are practically sure to be unsatisfactory.

However, it should be remembered that even drives in the third class can be made to work temporarily if sufficient tension is used on the belt. Also, the reverse is true in that drives in the first class may cause trouble if they are not kept tight enough. The tables apply to belts under average tension, but are liberal enough to allow for considerable variation in tension, providing the belt does not slip excessively.

Belts may be occasionally found which seem to be operating all right at shorter center distances than these, but the chances are that the belt is very tight or it is lightly loaded, or it may be held in position by a shifter fork or some other obstruction. The author frequently has had an opportunity to check these tables against actual installations, and has almost invariably found the above to be true.

Misalignment of the shafts, or moving one pulley on its shaft, might occasionally help to keep the crossed belt on the pulleys, but our experiments indicate that little can be

gained by these devices. If the shafts are thrown out of alignment to keep the belt on at full load, it will tend to run off the opposite edge of the pulley at lighter loads, and *vice versa*. Or, if one pulley is offset the belt will tend to follow this pulley, and remain in about the same position on the pulleys. If the load is very constant, offsetting of one pulley may sometimes be used to advantage. Misalignment of the shafts should never be recommended. The center distances given in the tables are based on perfect alignment of the pulleys and shafts.

With any crossed belt under load the force tending to keep it on is the climbing action of the belt on the crown of the pulleys. The principal force tending to push it off is the pressure of the tight strand of the belt against the loose strand where they cross. As the load is increased the tension on the loose side is decreased. Naturally, the tight strand displaces the loose strand and forces it from its path so that it approaches the driven pulley at a slight angle. The greater the load the greater this angle becomes, until the practical limit is reached at the point where the tight side has nearly displaced the loose side. This displacement is greater than it appears at first thought because of the twist in the strands. Therefore, there is always a force tending to run the belt off the pulleys, but it depends upon the pulley sizes and center distance whether or not this force is great enough to overcome the climbing force caused by the pulley crown.

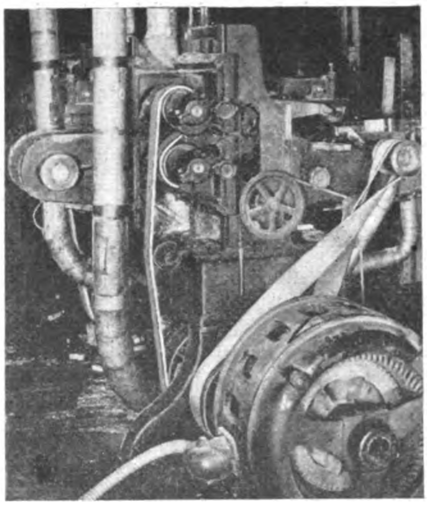


Fig. 5—Here is an example of a short-center belt drive over a small pulley.

This illustration shows very clearly the way one strand of the crossed belt pushes against the other. This small pulley is provided with a flange to keep the belt on. Courtesy of Chicago Belting Co., Chicago, Ill.

Table II—Minimum Center Distances for Crossed Belt Drives

Maximum Center Distance in Feet for Single Belts

Driven Pulley, Diam. in In.	Driver Pulley Diameter: 4 In. B	4 In. A	6 In. B	6 In. A	9 In. B	9 In. A	12 In. B	12 In. A	18 In. B	18 In. A	24 In. B	24 In. A	36 In. B	36 In. A
4	..	..	..	..	..	..	13	c18	c†22	...	...	...	...	...
6	..	..	..	..	..	..	12	c14	c†18	c20	c†20	c22	...	...
9	..	..	..	..	..	..	9	9	12	12	15	c17	...	...
12	*10	*10	8	8	8	8	8	8	9	9	11	11	c18	c20
18	*10	*10	8	8	8	8	8	8	9	9	10	10	c15	c17
24	10	10	8	8	8	8	9	9	9	9	10	10	11	11
36	10	10	10	10	10	10	10	10	11	10	11	10	14	13

Maximum Center Distance in Feet for Double Belts

Driven Pulley, Diam. in In.	Driver Pulley Diameter: 6 In. B	6 In. A	9 In. B	9 In. A	12 In. B	12 In. A	18 In. B	18 In. A	24 In. B	24 In. A	36 In. B	36 In. A
6	..	..	..	..	16	16	c16	c18	c20	c22	...	...
9	..	..	..	..	8	8	9	9	12	12	...	...
12	8	8	7	7	7	7	9	8	9	9	c17	c19
18	8	8	7	7	7	7	7	7	9	9	11	c15
24	10	10	7	7	7	7	7	7	7	7	11	12
36	10	10	8	8	8	8	9	9	10	10	15	10

DIRECTIONS FOR USE ON BOTH TABLES:
Use for belts up to 6 in. wide.
Reverse cross if drive does not work well.
B and *A* indicate tight side below or above driver pulley.
* For belts below 3 in. wide use 8 ft. center distance.
† For belts below 3 in. wide use 17 ft. center distance.
c Calculated or estimated.

When a small pulley is used with a larger one, as illustrated in Fig. 4, the point where the two strands of the belt cross is nearer the smaller pulley. As the loose side, which is forced aside at the cross, always comes on the driven pulley, this force will be applied nearer the driven pulley when the larger of the two pulleys is driving. Therefore, for any given pulley combination, the minimum center distance for stable operation will be greater when the larger pulley is driving. Anyone who has tried to run a belt off with a stick has noticed that it is much easier if the force is applied on the loose side near the driven pulley, instead of half-way between the two pulleys.

To illustrate further, suppose that the smaller pulley in Fig. 4, is driving and strand-1 is the tight side. Then strand-1 will be forcing strand-2 aside as it comes on the larger pulley, but since the cross is too far away from the large pulley this force is not sufficient to overcome the effect of the crown. If the larger pulley is driving with strand-1 as the tight side, strand-2 is being forced aside much nearer the small pulley, which it is approaching, and the belt is more likely to run off. It is desirable to have the point of crossing 4 ft. or more from the driven pulley, depending on the pulley combination used. Reversing the cross is frequently of benefit.

The same reasoning applies in explaining why an increase in tension makes the crossed drive more stable. When the initial tension is increased, there is a readjustment upward of the actual tensions in the two strands, so that the loose side is carrying a greater proportion of the total tension than it was formerly. The result is that the loose side, being under a greater relative tension, will not be pushed aside to the same extent until greater loads have been reached. Furthermore, the climbing action due to the crown probably becomes greater as the tension is increased.

Briefly some of the more important results and conclusions on the operation of crossed belts are as follows:

(1) The crossed belt transmitted 10 per cent more power than the normal belt in an average of three tests, but as it is more unstable in operation no higher power rating is recommended.

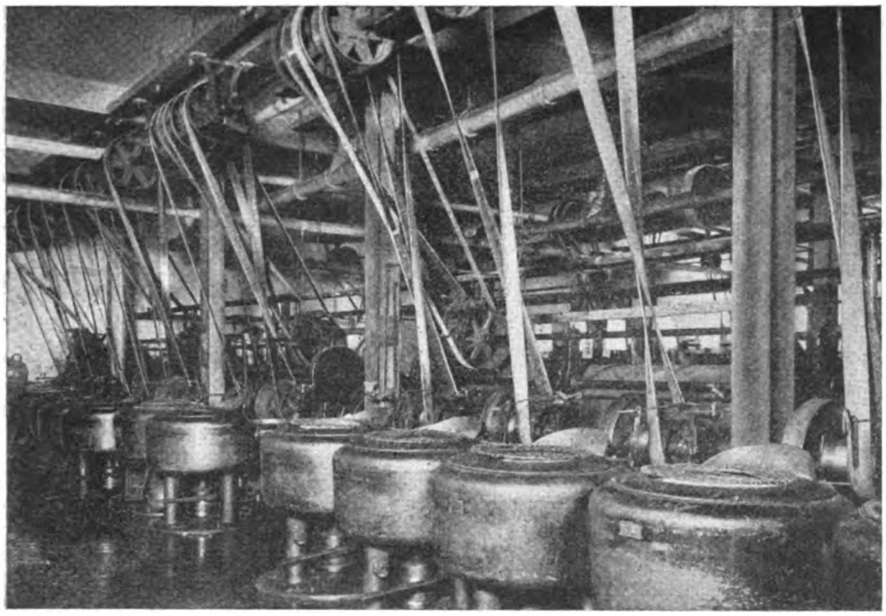


Fig. 6—**Many of these centrifugal machines in laundries use crossed belts on tight and loose pulleys.**

This type of service throws a heavy load upon the belt drive whenever the belt is shifted onto the tight pulley. These center distances, however, are great enough to prevent belts running off the pulley. Courtesy of Chicago Belting Co., Chicago, Ill.

(2) Every crossed drive seems to have a minimum center distance below which the drive is unstable and its performance unsatisfactory.

(3) Using the smaller pulley as the driver makes a more stable drive, and it can be operated at a shorter center distance than when the large pulley is used as the driver.

(4) The higher the initial tension, the more load a crossed belt will carry without running off.

(5) Belt speed does not affect the performance of a crossed belt, except for the usual effect of centrifugal force on its transmitting capacity.

(6) Belts of any width up to 6 in. seem to work about alike on the crossed drive, with a few exceptions noted in the tables.

(7) Double belts work a little better than singles on many crossed belt drives.

(8) Using the tight side of the belt above the smaller pulley, whether it is driving or driven, is a more stable condition than using it below.

(9) The rubbing at the cross tends to reduce the co-efficient of friction, more or less depending on the belt.

The direction of the cross has an important effect on crossed belts, because one edge of the belt is usually a little longer or more elastic than the other. If the longer edge is on the wrong side the crown will not hold the belt on as well as though the cross were reversed. The cross may be reversed by removing the belt from one pulley and untwisting one-half a turn as if to put on an open drive and then twisting another half turn in the same direction. This changes the position of the two strands at the cross, so that the tight side tends to force the loose side off in the opposite direction from that in which it did before. When a crossed-belt drive which has been correctly laid out refuses to work properly the trouble can usually be remedied by reversing the cross.

Arc Welding in Maintenance Work

(Continued from page 266)

Recently new tubes were arc-welded in the top sheet of a locomotive crane. Plans are under way to arc-weld in the tubes at both ends in another locomotive crane in which the tubes must be renewed shortly.

The hood and smoke pipe on a large blacksmith's forge in the repair shop were constructed by arc-welding the steel sheets together. The repair men have also used the welder to a considerable extent in building up miscellaneous fixtures around the repair shop as, for instance, horses for holding work. They also built up a light, portable forge which can be connected onto an air line anywhere in the plant.

In dismantling parts which have been riveted together, the torch is used for cutting out the rivets; frequently the new parts are arc-welded.

There are, of course, numerous broken castings which must be welded. Those of cast iron, and sometimes cast steel, are usually welded with the acetylene unit and are preheated on our special bench.

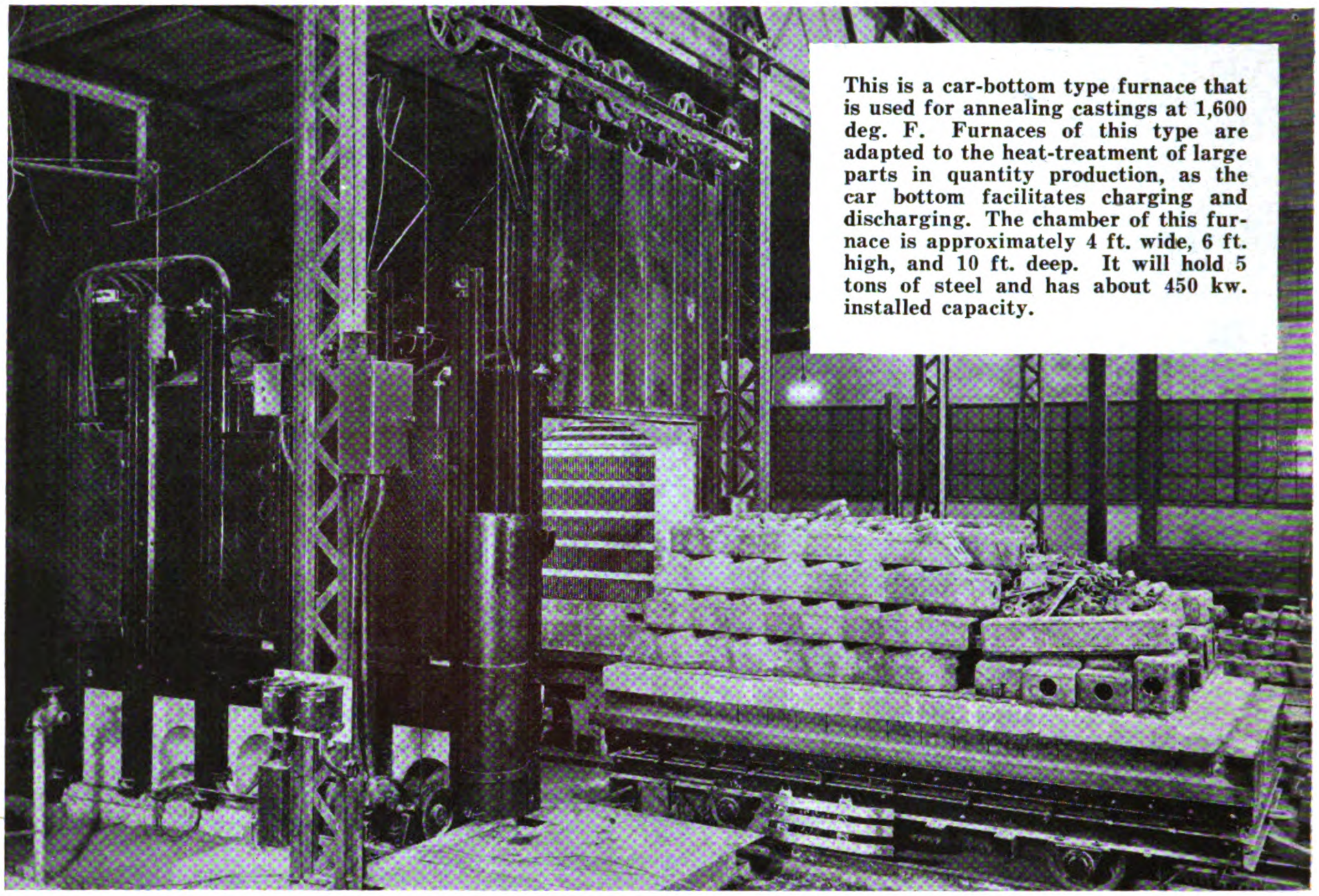
The gas-cutting and arc-welding units are used in combination on a wide variety of jobs. A recent job, for instance, consisted of constructing some special brackets from ½-in. steel plate. These brackets had two bends, each of about 120 deg. Instead of heating up the steel plate in the forge and then making a hot bend, the welder cut a slot through the plate, except for about ½ to ⅝ in. at the edges, or just enough to hold the plate together, at the place where the bend was to be made. The bends were then easily made cold, and also very accurately. After bending the plate, the slot was filled in with the arc welder. A 1½-in. by ⅜-in. flat bar was bent into a half-circle and welded into a semi-circle cut into the top of the plate. This formed a saddle to hold the gasoline tank on a special industrial truck. One of these pieces is shown in the group of welded parts in the illustration on page 266.

This list by no means represents anywhere near the amount of work done. The group of jobs illustrated indicate only those in the shop at the time the photographs were taken.

At first we intended to use the welding units only to repair broken parts; now, however, the use in building up new parts equals if not exceeds the time spent in the actual repair of old work. Every day we are finding something new to weld.

It is our aim to provide a variety of electrodes so that any type of work may be handled. Only small amounts of some of these types are used; others are used in considerable quantities. The accompanying list shows the different types of electrodes carried in stock and the average quantities used monthly. Where the table mentions "small amount," this indicates that the particular electrodes are carried in stock but are used infrequently.

Because we use one type of welder for certain classes of work and the other welder for other jobs should not be taken to mean that this is the best or only way. Another operator with different training might handle our welding work in other ways, to suit his training and experience. However, we are well satisfied with our method of dividing the work, which in general follows the lines described, although this is not a hard-and-fast rule.



This is a car-bottom type furnace that is used for annealing castings at 1,600 deg. F. Furnaces of this type are adapted to the heat-treatment of large parts in quantity production, as the car bottom facilitates charging and discharging. The chamber of this furnace is approximately 4 ft. wide, 6 ft. high, and 10 ft. deep. It will hold 5 tons of steel and has about 450 kw. installed capacity.

Factors that determine when

Electric Heating Can Be Used to Advantage

in industrial plants, with a discussion of the operating economies and desirable features that are inherent in this mode of heating

By WIRT S. SCOTT
Special Representative, Industrial Heating, Westinghouse Electric & Mfg. Co., Mansfield, Ohio

TWELVE years ago, when the first real start was made in the study of industrial heating problems, almost nothing was known of the economies that might be expected to result from the use of electric energy. A prospective user who was willing to let an electrical manufacturer conduct experiments in his plant, at the expense of said electrical manufacturer, was exceeding the height of magnanimity.

Everyone was skeptical and most people positively antagonistic, due to their accustomed practice and usage of fuel-fired equipment, which had been handed down from one generation to the next.

As years went on and the usage of electric heat increased, the time approached for encouraging the user to make preliminary investigations himself for the purpose of calling attention to the advantages of electric heat when applied in his manufacturing processes.

Today, due to the fact that sufficient interest has at last been aroused and a sufficient number of diversified installations have been made, the time is opportune for showing the industrial plant operating executive how to convince himself as to whether or not he should use electric heat, and after he has decided for himself, to see that he gets the proper kind of apparatus to perform his heating operation most efficiently and economically. The equipment may be especially designed, if need be, to meet his particular plant conditions.

Electric heat has a definite field of operation at the present time. In listing the following conditions of operation that may exist in an industrial plant, it is not done with the intention of dwelling on the advantages of electric heat, but rather for the purpose of showing definitely wherein electric heat is applicable and will prove to be commercially economical.

(1) In a plant producing the highest-grade article, where a new standard of comparison will be of advantage from a business standpoint, electric heat will make it possible to set up new standards.

(2) When a good product is already being secured, electric heat will make it possible to produce a better product.

(3) When a non-uniform product is being secured, electric heat will

make it possible to produce a uniformly high grade of product, with elimination of rejects and reduction in the amount of labor required, resulting in lower cost of production.

(4) When continuous and uniform production of a good product is required, electric heat will give continuous output with elimination of rejects.

(5) When the present grade of product is satisfactory, electric heat will oftentimes permit the use of less expensive materials.

(6) When a lighter product is desirable, or where a saving could be effected through the use of lighter materials, provided these have sufficient strength, electric heat will make possible such savings. Through its use the utmost strength or hardness can be imparted to the materials, and these results can be duplicated day after day, continuously.

(7) When it is desired to reduce the amount of labor to a minimum, electric heat will make for reduced labor in operation of apparatus, reduced labor in handling materials, and reduced labor in maintenance of equipment.

(8) Where it is desired to improve working conditions, the use of electric heat will result in elimination of hot gases that must be breathed by the workmen, elimination of overheated workrooms, increasing efficiency of labor, provide better humidity conditions, and permit of more definite control of ventilation.

Heat in some form enters into the production or fabrication of all manufactured materials. The quality or characteristics of the final product depend upon the exactness of the heat-treatment. Inferior raw material that is properly heat-treated may provide a much better product than will a superior raw material that is improperly heat-treated.

Heat in one way or another affects the quality and cost of practically every manufactured article. The problem resolves itself into selecting the combination of raw materials, methods, production equipment, facilities, and personnel, which when properly adapted to individual manufacturing requirements and plant conditions, will most nearly accomplish the desired results; that is, the production of a quality product at a minimum cost. Quality and cost of the finished product are the basic factors that must always be considered.

Fuel cost is but one item in the final cost of production, and in most cases it is only a small item in the total cost of the finished product. The cost of fuel or power may influence, but certainly does not determine, the cost of the completed product. Electric heat is the ideal heat, and in many cases it is the most economical means of heating, when all factors are considered.

Electric Heat Permits Close Time and Temperature Control

The development of heat-treating processes to a high plane has been practically impossible in the past, due to the nature of the fuels available. To secure a predetermined product, it is essential that the complete time-temperature cycle of operation be under definite control, that the heating be done in a chamber having uniform temperature distribution, in an atmosphere free from products of combustion, and in a minimum length of time. With combustion fuels, these results can be only approximated, and with no definite assurance of duplication day after day of a uniform product.

With fuel-fired furnaces a metallurgist, physicist or chemist will take a sample piece of his product, accurately determine by a series of experiments in a small electric furnace the best time-temperature cycle of operation, and turn these specifications over to his shop with the expectation of this result being duplicated in a furnace incapable of reproducing the conditions obtaining in the laboratory experiments. Appreciating more or less the limitations of fuel-fired furnaces, metallurgists and operators both have adopted the results obtained as standards of best practice, and have had to adapt their materials to the nature of the heat-treatment, instead of adapting the heat-treatment to the nature of the material.

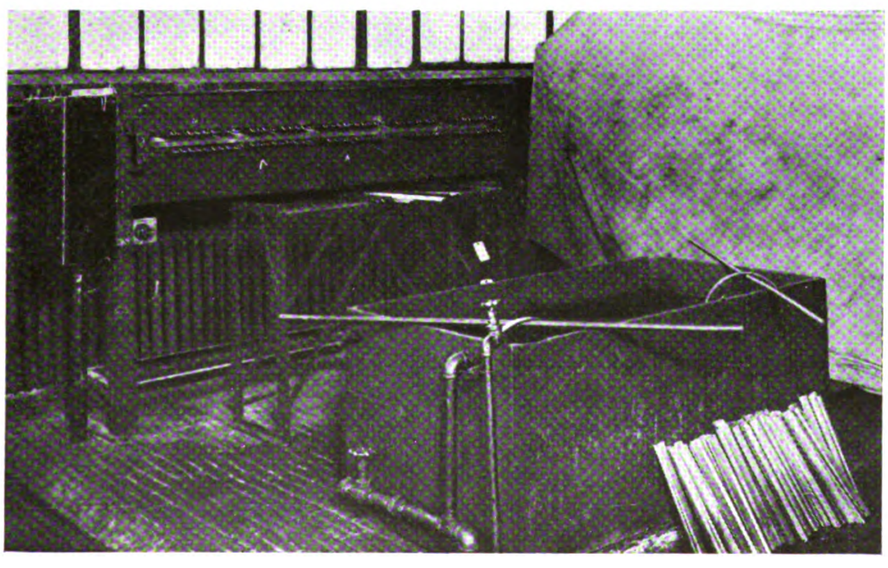
There is now on the market dependable electrical heating apparatus for securing these results. This apparatus is capable of duplicating in shop practice, day after day, continuously and entirely automatically, an exact or defined time-temperature cycle, as required by the specifications.

Every known kind or piece of material heated has its quality affected by the heat-treating process. Also, every known material has some definite best temperature for producing the best quality possible with the material used. The nearer one approaches to these ideal conditions, the nearer perfection will be secured in heat-treatment work. Likewise, the farther one departs from the ideal best temperatures, the less satisfactory will the product be.

The advantages to be gained by using electric heat will depend upon the specific application. In the applications now in general use, it produces certain results that might be said to be inherent with electric heat. These results are, uniform high-grade quality of product, increased production, reduced expenditure for labor, better working conditions, and lower over-all operating results. These are a logical consequence of

Here is a special furnace that was built for a special job.

This 15-kw. furnace is used for annealing turbine blades at 1,300 deg. F. This is a case where it was more economical to build a special furnace than to use one of standard construction and design.



the fact that electric heat is the most flexible and the easiest-controlled form of heat that can be used.

The truth of these statements will be readily appreciated by considering the following points:

(1) Heating units, in suitable form, may be distributed in an oven or furnace or attached to a tank, table or machine, in the correct manner to give a uniform distribution of heat, in just the quantity desired. Once these conditions are secured, they become fixed for all time, and are not subject to change or variation, as when a combustible fuel is used. This condition results in a better product, increased production, and increased output per unit of floor space or for each piece of apparatus.

(2) By means of automatic temperature control, the work will not be overheated nor underheated, but maintained at the correct temperature, continuously and automatically.

(3) By means of electric heat, automatically controlled, tests can be made to determine the proper rate of heating, the best temperature for accomplishing the desired results, and the length of time the work must be subjected to a given temperature to produce the desired results. Once these conditions are determined, the desired product can be reproduced day by day, automatically, with the same uniform results. Electric heating has made possible the duplication of laboratory experiments in shop practice.

The greatest progress in the application of electric heat has been made with manufacturing plants that keep accurate cost records of each phase of operation affecting the cost of the completed product. Factors that affect costs were not overlooked, and these plants were in a position to determine the value of electric heating by an accurate comparison of this with other methods of heating, taking everything into consideration. The cost of fuel or power is only one item affecting costs.

Making an Investigation of Operating Conditions in the Plant

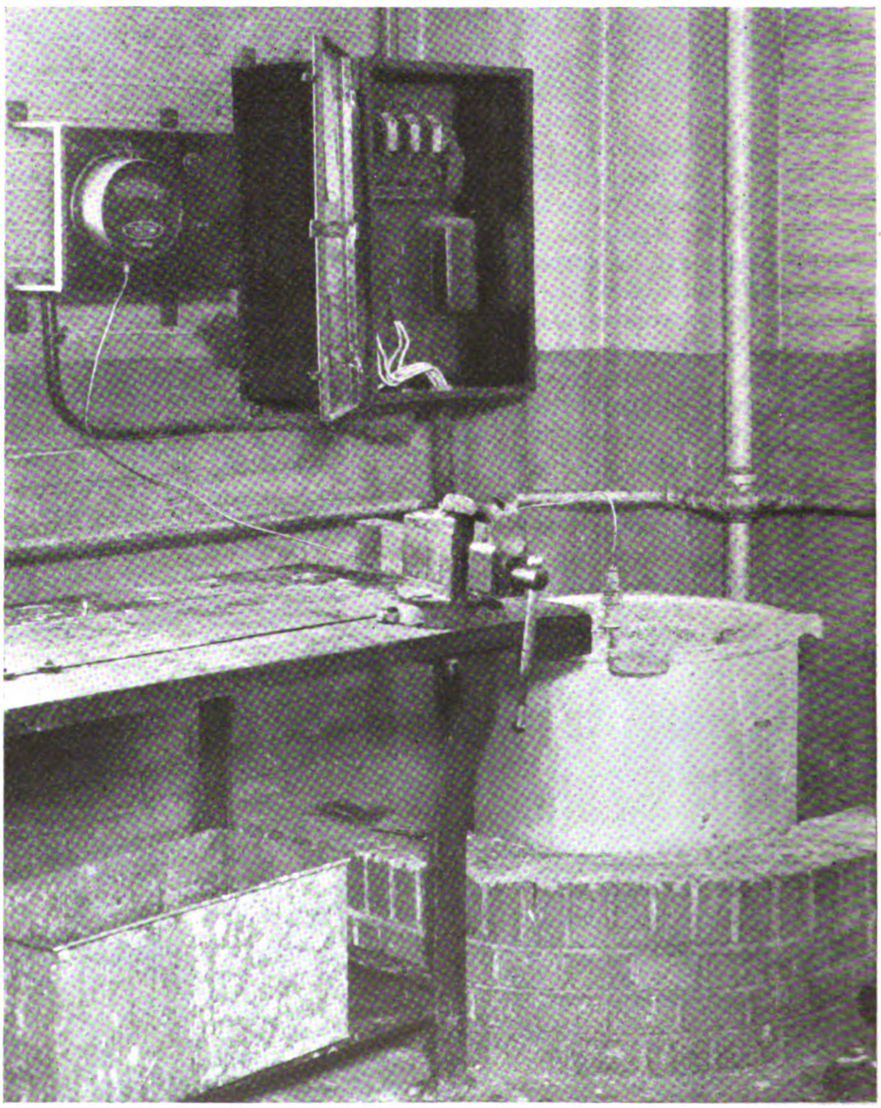
The first step in an industrial electric heating investigation must be made for the purpose of securing a detailed knowledge of the operating conditions. Consideration must be given to all phases contributing to the production of the completed product. Among these factors are:

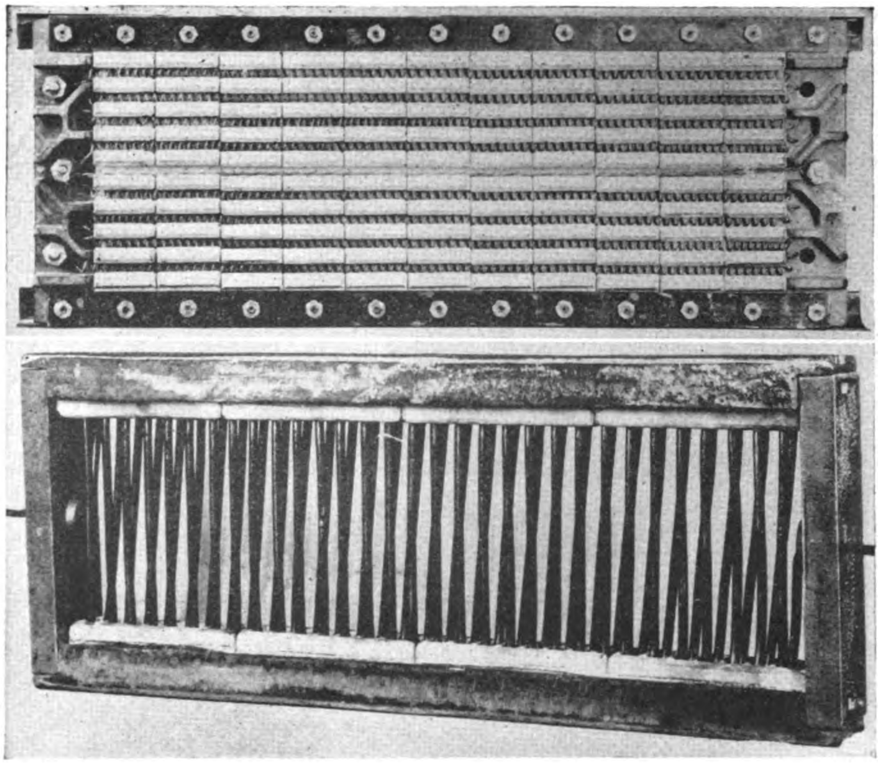
Quality of Product—A high-grade quality of product has a high sales price. The finished product may be made up of a number of component parts requiring the use of heat during some stage of manufacture. Determine what these parts are. It will then be in order to find out how much more could be obtained for the product, or how much sales could be increased if a better product were possible.

Uniform Product — A *uniform* product is desirable, whether it be uniformly good, uniformly fair or uniformly poor. If a product is excellent one day and only fair the next, or is otherwise non-uniform, the manufacturer is saddled with an unnecessary expense, for the following reasons: (1) Where the manufacturer demands only a high-grade product, all production that does not come up to such specifications must be rejected. Consequently, the cost of producing material which does meet the specifications is increased, resulting in increased selling price or decreased profits. (2) Where the product is sorted into two or more grades, a lower price must necessarily be obtained for the inferior grade or grades. (3) Where the entire product is sold as one medium grade, the manufacturer is penalized for his inability to produce all high-grade material, through the production of an excessive amount of low- or second-grade material.

The first step is to determine the reason for non-uniform product. If this can be traced to the heating of any component part of the material, in any stage of its manufacture, determine the cause as accurately as possible. There may be several contributing factors, such as (*a*) incorrect temperature to produce the best results. To check this point, tests can be made in a small oven or furnace on samples and the correct

This 750-lb. melting pot is used for tinning leads and terminals for electrical equipment. The control panel can be seen mounted on the wall at the left.





These are heating units used in electric furnaces.

The upper view shows a medium-temperature unit rated at 2.5 kw. at 900 to 1,300 deg. F. or 5 kw. up to 900 deg. F. It may be operated directly on 110 or 220 volts. In the lower view is a high-temperature heating unit with a rating of 8 kw. at 1,800 deg. F. or 1,600 kw. at 1,500 deg. F.

temperature determined for securing the quality of product desired. These conditions can then be duplicated, automatically, day after day, by the use of electric heat. (*b*) Inability to control the temperature within close limits. By means of electrically controlled heating equipment, the temperature of any heating operation can be made simple, reliable, automatic, and as close as may be desired. (*c*) Heat not applied uniformly. Electric heaters in suitable form can be applied to any process, to give a uniform distribution of heat continuously and automatically. (*d*) Heating done too slowly or too rapidly. By the use of electric heating equipment, a system of control can be used which will accommodate itself to any cycle of heating operation so as to heat the material at the predetermined rate found from experience to produce the best results. (*e*) Work injured by a high flame temperature. Electric heat-treating is accomplished at relatively low temperatures, the temperature of the heating elements never being many degrees above the temperature of the work, so that there is little danger of local overheating.

Production—The items entering into production, in so far as heating is concerned, that affect the cost of the finished product, are: (*a*) Interruptions caused by the failure of the heating medium, which may be due to failure of the equipment, shutdowns for repairs, or failure of the source of heat. (*b*) Reduced production due to difficulty in retaining skilled labor. (*c*) Non-uniform production due to the human element in the handling of material or operation of the heating device or apparatus. (*d*) Overhead charges for labor, supervision, plant equipment and floor space. (*e*) Number of rejected parts and number of parts that have to be reheated in order to pass inspection. (*f*) Additional labor required in other departments, to handle material that has been rejected or is defective due to improper heating.

Considering heating operations, the items that influence the cost of the labor involved in turning out the finished product are: *Labor*—(*a*) Labor required in handling the material. (*b*) Labor required in operating or supervising the operation of the heating device or apparatus. (*c*) Saving in labor if conveyors or trucks could be used. (*d*) Saving in labor if the heating operation could be made automatic. (*e*) Effect on the workmen of present conditions, such as exposure to excessive heat, or the breathing of gases and poisonous fumes.

Fires or Explosions—These have been the cause of much property damage and loss of life. They may be due to the form of heating medium, kind of heating apparatus used, careless workmen, nature of material heated, and a number of other factors.

Inasmuch as fires and explosions do not occur every day, it will be necessary to go back over the records for a period of years to determine whether any have occurred, and the extent and nature of the damage done.

Maintenance—In the maintenance work required for the heating equipment, following items should be considered: (*a*) Annual repairs to heating equipment, taken over a period of a number of years. These repairs should include all labor and material used in making such repairs. (*b*) The cost of operating all auxiliary equipment, such as blowers, compressors, and the like. (*c*) The handling charges for fuel, such as oil, coal, coke, and so on.

Penalties—Every plant that does not utilize electric energy for manufacturing processes that require heat is, to a greater or less extent, penalizing itself by not doing so; therefore, such penalties must be charged up against the present heating process as a direct expense. Among the items that must be considered from this standpoint are: (*a*) Low power factor. Heating equipment, with the exception of arc furnaces, operates at unity power factor, and will raise the power factor of any industrial plant. If the heating load is of considerable magnitude it will make it possible to obtain a better power rate of the entire electrical load of the plant. (*b*) Power rates. The addition of a heating load greatly improves the load factor and will make possible lower power rates for the entire electrical load of the plant.

A thorough analysis of these items will serve to establish a definite basis for the formulation of plans to improve present operating conditions, and enable the plant engineer to determine the influencing factors entering into the cost of the completed product. Only in this way can an intelligent selection of equipment be made.

After the above conditions have been accurately determined, and not until then, the cost of fuel, compared to the cost of electric energy for heating processes, may be given due consideration.

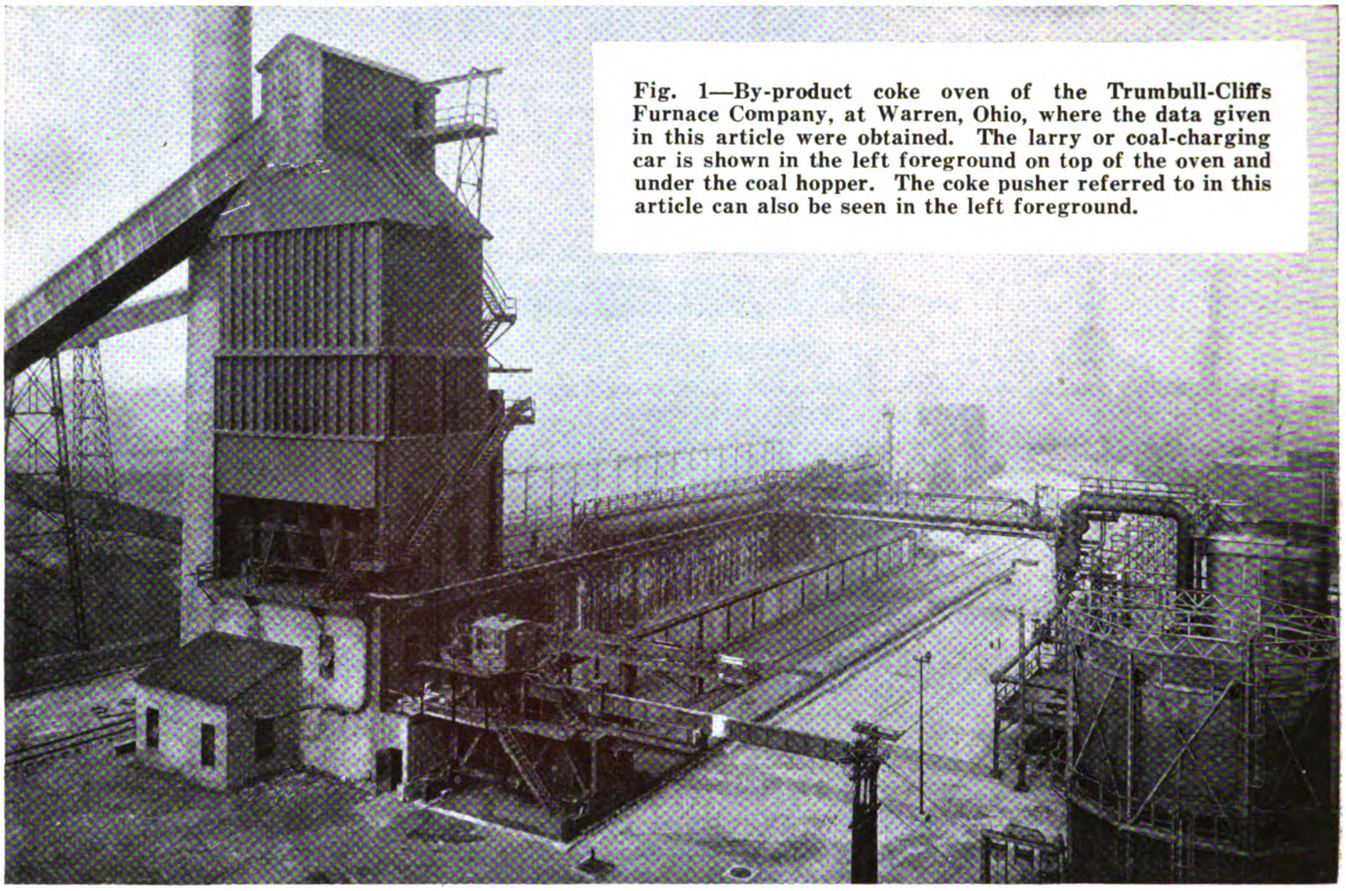


Fig. 1—By-product coke oven of the Trumbull-Cliffs Furnace Company, at Warren, Ohio, where the data given in this article were obtained. The larry or coal-charging car is shown in the left foreground on top of the oven and under the coal hopper. The coke pusher referred to in this article can also be seen in the left foreground.

Improving control operation by

Changing Resistance on Motor Controllers

used in a blast furnace and coke plant, together with a discussion of causes of troubles encountered and diagrams showing method of overcoming them

By O. C. CALLOW
Chief Electrician, Trumbull Cliffs Furnace Co., Warren, Ohio

IN THE application of variable-speed motors on machinery, a hazardous guess is often made as to the horsepower required of the motor. With the tendency of the designer to be on the safe side, the motors chosen are often too large for the job and if they are series wound, the speed of the equipment will frequently be much higher than was intended. This in turn affects the control of the motors, as the control manufacturer is called upon to furnish a controller which will be suitable to stop and start the motor to be used and supplies a standard controller for this rating together with standard resistance.

When series motors are used, overmotoring with its corresponding overspeeding will soon show up on the controllers, since there will be more "inching" in order to get slow operation of the driven equipment. By "inching" a controller is meant the operation of repeatedly moving the controller to the first point and then to the off position, thereby intermittently applying power and causing the motor to run slowly. It is, therefore suggested that every drive in a new installation should be carefully watched for the first few months to ascertain whether any improvements in operation could be made by using different values of resistance to help slow up any motors where excessive speed is causing trouble, thereby lengthening the life of the controllers and also of the mechanical drive equipment.

As an example of what improvements can be made in this line I will cite the case of a quenching locomotive in a coke plant. It pulls the quenching car which receives the hot coke as it is pushed from the oven and carries it to the quenching tower where water is poured over the car, thereby stopping further combustion of the coke. The equipment on this quenching car consists of two 90-hp., series-wound motors controlled by a series - parallel, manually - operated, drum controller. In pushing an oven the coke is to be distributed the whole length of the quenching car. This is done by moving the car forward as the oven is pushed. With the original equipment this was done by "inching" the controller on the first point, 22 times for each oven pushed; this meant breaking the acceleration current of the two 90-hp. motors over 2,000 times a day with the natural result that controller repairs were more frequent and costly than they should have been.

After a little study of this condition an extra bank of resistance

having an ohmic value of about 40 per cent of the total resistance was installed in the first step, as shown in Fig. 2. The amount of this additional resistance was adjusted during operation until it was found that with the controller placed on the first point when the coke commenced to fall in the car from the oven being pushed, the speed of the car would be just fast enough for it to travel its own length while the coke was falling, thereby distributing the coke from the oven evenly in the car. The operator is, therefore, relieved of the duty of "inching" and the movement of the car becomes nearly automatic on the first point of the controller. After the oven is pushed, he speeds up the car and proceeds to the quenching station as usual. The extra resistance is also of an advantage here in spotting, especially as the rails are wet at all times and wheel spinning is very likely to occur. Use of the additional resistance has eliminated all wheel spinning of the car while in the quenching tower. The installation of the extra resistance in this particular case was taken care of by the locomotive manufacturer when he was advised of the trouble. In any event the cost of the extra resistors would very soon have been saved in control segments and fingers, and in the labor of installing these.

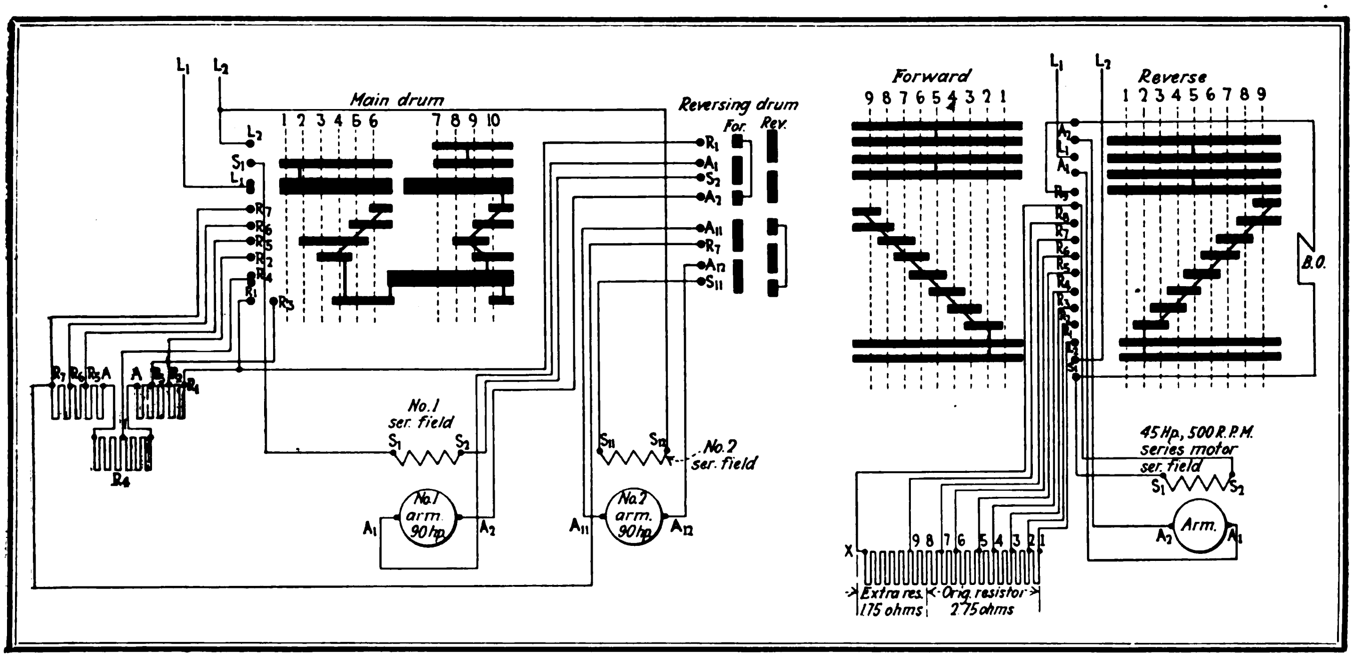
Another installation on the same battery of coke ovens was improved in a similar manner. The larry car (seen under the coal hopper in Fig. 1) that charges the coal into the top of the ovens has no need for high speed on the bridge or propelling motion, for the distance traveled on the top of the battery is short, as may be seen by inspection of Fig. 1, and normally a good deal of "inching" is required to spot the car hoppers over the charging holes in the ovens. This car is driven by a 45-hp., 500-r.p.m., series-wound, mill-type motor and controlled by a standard, manually-operated, reversing, drum controller provided with standard resistance.

Trouble was experienced on this drive by the operator plugging his controller too rapidly while the car was moving at high speed, thereby causing burning of the controller parts and sometimes opening the substation circuit breaker, causing a delay on the battery. Plugging a motor is the operation of reversing the power supply applied to it while the motor is running in a given direction. This action causes the motor to slow down, stop, and start in the reverse direction. By plugging the motor the need of a separate service brake is eliminated, for the plugging operation performs the braking required. As a cure for the trouble encountered, an extra resistance was added to the accelerating resistance, in this case consisting of a bank of grids and connected as shown in Fig. 3. The contact finger at *R*9 was removed so that it is impossible for the operator to cut out the new resistance in any position of the controller; hence this additional resistance is permanently in series with the armature. The original resistor had an ohmic value of 2.75 ohms divided into eight steps; the extra bank installed has an ohmic value of 1.75 ohms and has a current-carrying capacity equal to the full-load current of the motor. This resistance not only acts as a plugging resistance, but also limits the acceleration and running speed of the car, so as to make it more suitable for the short run required.

Another interesting problem was involved in the mechanical operation of the door hook on a coke oven pusher. The door hook removes the oven door from the pusher side of the oven so that the pusher ram may be placed against the hot coke and push it out through the opposite end of the oven. The coke pusher may be seen in the center foreground of Fig. 1. The door hook is on the oven end of the pusher. This hook takes very little power to operate, so the smallest mill-type motor available was installed, this being a 2-hp., 900-r.p.m., series-wound motor. It was found that unless the operator was very careful in his manipulation of the controller on this drive, he would over-run the travel of the nut on the driving screw, causing it to jam.

Figs. 2 and 3—Increasing the amount of resistance used on these controllers greatly improved motor operation.

In Fig. 2 is shown the diagram of a series-parallel drum controller for two motors used on an electric locomotive. Additional resistance was connected between the points *A-A* so as to eliminate the "inching" of the controller formerly required. Fig. 3 shows how an extra resistor was connected permanently in series with the armature of a larry car delivering coal to coke ovens, so as to prevent the operator from abusing his control through excessive plugging. The contact finger *R*9 was removed so as to prevent cutting out the resistance step between 9 and *X* on the ninth or last point of the controller.



This condition caused operating delays which could not be permitted.

One remedy which suggested itself was to install limit switches to limit the travel of the nut in both directions on the screw. Owing to the lack of space and also to the hot and dirty location in which the limit switches would have to be installed, it was not considered practicable to use them. Satisfactory operation has been obtained simply by installing more resistance in the motor circuit so that the speed of the motor is reduced. This cuts down the possibility of overtravel.

The resistance supplied with the drum controller on this drive consisted of 20 wire-wound tubes assembled in a box having a total resistance value of 25 ohms. This value was increased to approximately 40 ohms, which was found to give the desired results. The use of so much tube resistance in the operator's cab was objectionable as these boxes are difficult to mount and to repair. Consequently, an entirely new resistor was made up consisting of six standard 500-watt, 115-volt, space heaters. A space heater of this capacity has a resistance of approximately 26.5 ohms and a full-load current rating of 4.35 amp. Using two space heaters in parallel gives sufficient current-carrying capacity and to secure the necessary value of resistance, six units were connected in series-parallel, as shown in *A* of Fig. 4, giving a total resistance of 39.75 ohms. These heaters were bolted into a strap-iron frame and fastened to the wall of the cab.

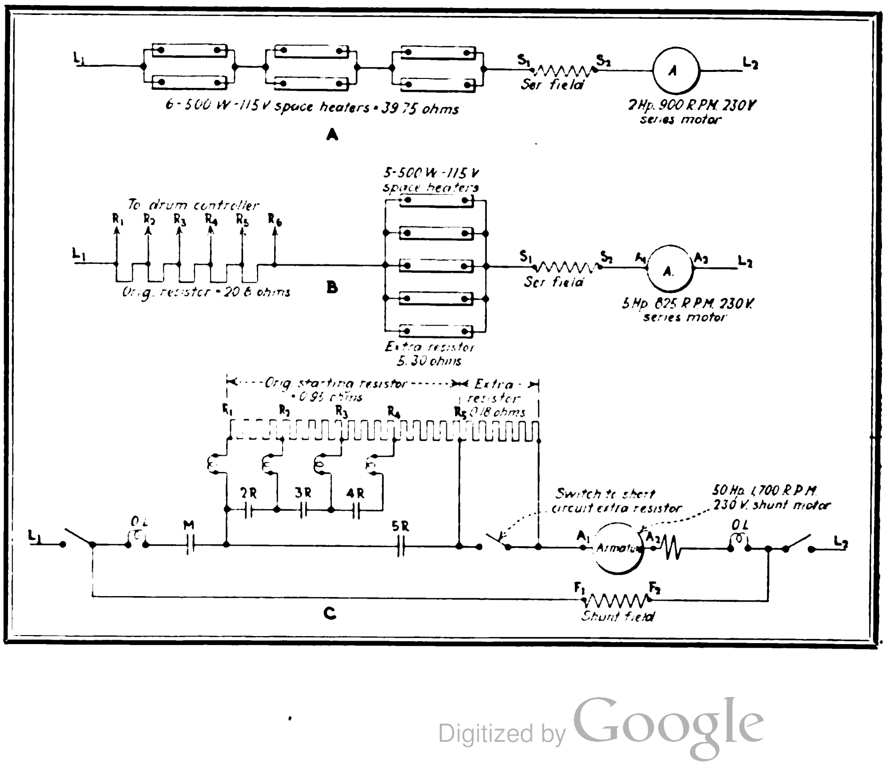
There are quite a number of places where space heaters will be found to work very satisfactorily as resistors when the current handled is not over 15 or 20 amp. On one installation consisting of a 5-hp., 825-r.p.m. series motor driving a pusher door ram, a permanent resistance was installed to prevent overspeeding of the motor. This installation was made up of five 500-watt, 115-volt space heaters connected in parallel as shown in *B* of Fig. 4.

Having shown the improvement that can be made in the operation of some variable-speed motors by the introduction of additional resistance, let us consider a special case involving a constant-speed drive which was improved in the same manner. Three 50-hp., 1,700-r.p.m., 230-volt, shunt-wound, constant-speed motors were installed in a boiler house and were coupled directly to three forced-draft fans. Trouble was experienced with these motors at first through overheating and poor commutation. When a test was made it was found that the line voltage was 250 volts instead of 230 volts. This excess voltage caused an increase in speed of the motors from 1,700 r.p.m. to about 1,840 r.p.m. At this speed the fans were delivering more air than was required and, since the horsepower required by a fan varies directly as the cube of the speed, the motors were working under a continuous overload, thereby causing the overheating and bad commutation previously mentioned. It was not possible to lower the voltage on this circuit without affecting the voltage of the whole plant; so a permanent resistor was designed for use with each motor to cut down the voltage across the motor terminals to 230 volts and bring the speed down to 1,700 r.p.m. This resistance, which has an ohmic value of 0.18 ohm, was built up of standard grids having a continuous current rating of 200 amp. and, therefore, operates at a low temperature which means long life and little maintenance. A knife switch was installed to short-circuit this extra resistance in case of an emergency when extra air might be required through failure of one of the fan motors, in which case the remaining motors could stand an overload for a short time. Since the installation of this resistance, the operation of these motors has been perfect and a considerable saving has been made in brushes, commutator wear, and possible armature rewinding, with the advantage that this equipment requires very little attention from the maintenance men, leaving their time free for other duties. Diagram *C* of Fig. 4 shows the connections of the above fan motors and indicates where the extra resistance was inserted.

A quick method of calculating the amount of resistance required for a given motor is to divide the line voltage by one and a half times the full-load current. Thus, resistance = (line voltage ÷ full load current × $1\frac{1}{2}$). This value of resistance will allow an inrush of less than 150 per cent full-load current, which is permissible in most cases, since the resistance of motor leads, interpole coils, etc., will be included and may reduce the inrush 10 to 20 per cent. If the resistor is installed with an ohmic value calculated as above and taps provided, it is an easy matter in case of necessity to cut out a little resistance after the equipment is put into operation: much more easy, in fact, than to add more resistance. Another advantage is obtained by having a little extra resistance available; in case a grid fails the tap can be changed, thereby putting one of the extra grids into service.

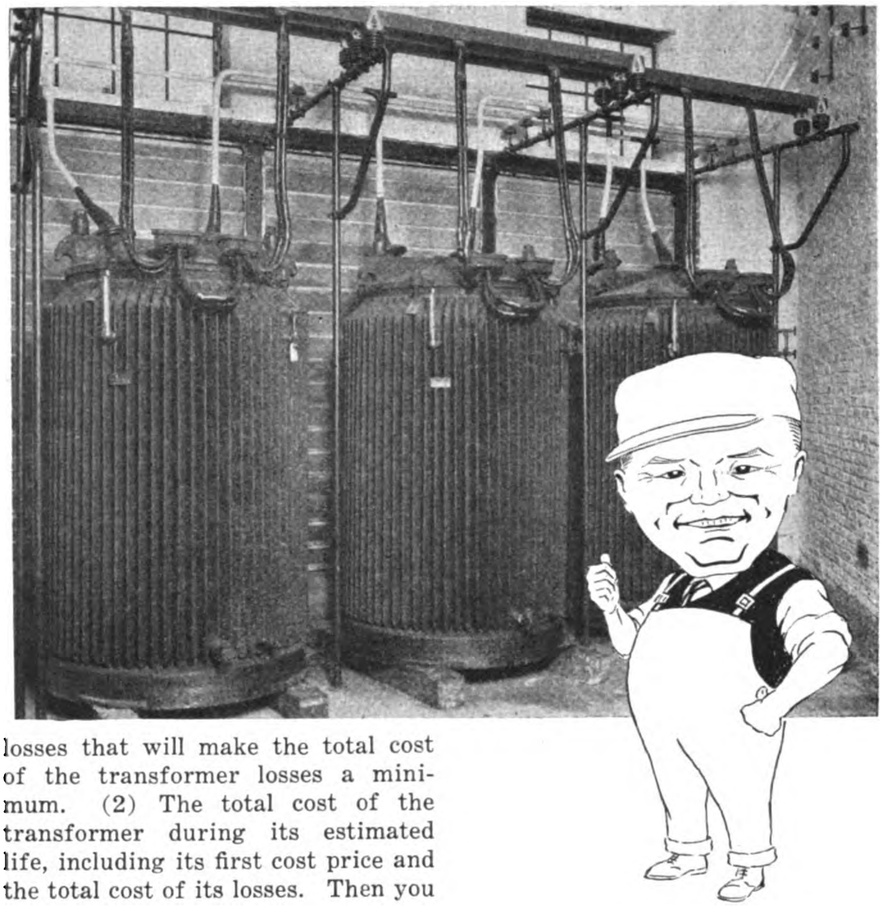
Fig. 4 — On small motors space heaters were used to advantage as resistors.

Diagram *A* shows the resistor arrangement for the door hook motor on a coke pusher. Six space heaters were connected in series-parallel so as to provide a total resistance of 39.75 ohms. Diagram *B* shows how space heaters were connected in series with the armature of a 2-hp. series motor so as to prevent overspeeding. Diagram *C* shows how resistors were used with a 50-hp., 230-volt. fan motor to permit operation on a 250-volt supply without overspeeding and thereby overloading the shunt motor



Facts for Your Transformer Data File

With a few pointers on checking up your own knowledge on the subject



TODAY less attention is given to a transformer serving an industrial plant than any other piece of electrical apparatus after it has been installed. It has no moving parts and, therefore, has no squeaks nor groans to indicate the want of attention, and unless lightning comes along and plays havoc with the windings, the transformer stays on the job in spite of the mistakes or the indifference of the men whose job it is to look after it. As a matter of fact, some transformers that have been on the job for the past ten or fifteen years should be given a permanent vacation in a nearby junk yard. A transformer will never actually wear out, but it will get so old, based on the core losses of newer designs, that the cost of energy to supply these losses will more than justify the purchase of new units on the basis of the possible saving in energy actually consumed in the transformer itself.

Except when used by central station companies, power transformers are often purchased today like sugar and salt, as needed and with few questions asked except the price and the delivery date, and the delivery date will frequently be the deciding factor simply because someone has delayed an investigation of the subject and finds himself forced to buy a pig in a bag because he must have a transformer on a certain date.

It is my purpose on this occasion simply to point out a few things about the selection and purchase of transformers. For instance, when you are called upon to buy a transformer for a particular service, low price and light weight are not a good basis to use. You should know how to determine the following points: (1) The ratio of iron and copper losses that will make the total cost of the transformer losses a minimum. (2) The total cost of the transformer during its estimated life, including its first cost price and the total cost of its losses. Then you should know something about transformer construction in order to purchase designs and sizes that will be suitable for changes and rearrangements that come about as time goes on and operating conditions change.

The bulletins of manufacturers often furnish much good, practical information along these lines and engineering handbooks contain some useful suggestions, but the best source of information is articles published by men who have given serious thought and study to transformer problems. There is one little publication that gathers up these practical articles and reprints them and from this I personally get a lot of practical pointers and think enough of it to carefully file it away for handy reference. This little publication is called "Kuhlman Kurrents" and is issued each month by a transformer manufacturer. If you would like to know how to secure a copy of this publication I will be glad to give you the mailing address, if you will drop me a note asking for it. Then again, there are at least two bulletins issued by The Electric Power Club that every operator should have in his information file. These are known as "Transformer Standards" and "Instructions for the Installation, Operation and Care of Distribution Transformers." These two copies will cost you about 60 cents but once you have them you would not part with them at any price.

These days, if you are going to stay in the electrical game, you must be an "Iser and not a has-been" as Elbert Hubbard used to say. And since I find that industrial plant men know less about transformers than they know about much more intricate electrical equipment, it seems to me a good chance for the energetic young fellows to get into the first ranks of those familiar with this subject as applied to industrial plant work, for you never know when you may be called upon to say you do or you do not know enough about transformers to spend your firm's money and get proper value therefor, or to tell when old units are costing too much money from high core losses to keep them in service.

Practical Pete

INDUSTRIAL ENGINEER
Devoted to the Maintenance and Operation of
Electrical and Associated Mechanical Systems in Mills and Factories
G. A. VAN BRUNT, Managing Editor

Draw on the Experience of Other Men in Solving Your Problems

IF ONE chooses he can go his own way alone, in so far as his job is concerned, handling it to the best of his ability and asking no questions of anyone. However, unless he is possessed of unusual ability the chances are that he will not accomplish the results or attain the success that could be his if he would avail himself of the knowledge born of experience that other men working along similar lines could give him.

Therein lies the value of technical publications and the various engineering societies and associations, such as the Association of Iron and Steel Electrical Engineers, whose Twenty-second Annual Convention is announced on another page of this issue.

On the one hand, technical publications bring to your desk a written, continuous record of the progress made by other men working in their particular fields. On the other hand, attendance at gatherings of the character indicated above affords an opportunity to meet and discuss with men of wide experience those problems which must be met and solved in every industrial plant. After all, these problems differ, for the most part, in detail rather than in principle.

Apart from the valuable and inspiring friendships that are certain to result, the opportunity of drawing upon a storehouse of knowledge that represents more experience than one could hope to obtain in several lifetimes, should be regarded as a privilege that is not to be taken lightly.

Do Not Let Quick Decisions Get You Into Trouble

SEVERAL serious blunders which were made by a young operating executive, and eventually led to his removal from a position of authority, were said by some of his associates to be due to a lack of engineering knowledge. In expressing this opinion these fellow-workers made the same sort of error that led to the other fellow's downfall—they took a snap judgment without knowing all of the circumstances. As a matter of fact, this young engineer did not lack either training or experience, but when he had to decide several important matters he gave his decisions on the spot, with no apparent study or foresight. Under the circumstances, his decisions were little more than guesses—and it turned out that his guesses were wrong.

Whether his actions were due to a desire to appear more competent than he really was, or whether they were the result of mental laziness that kept him from digging out all of the facts, need not be discussed here. There is no doubt however, that many errors of judgment in engineering matters are the result of snap decisions or guesswork, rather than a real lack of sufficient technical knowledge or experience to solve the problem correctly.

In many cases, when trouble with equipment is traced down it is found to be due to misapplication rather than to any real defect in design or manufacture. Someone who did not take the trouble to determine all of the facts tried to make the equipment do something, or operate under conditions, for which it was not suited, and trouble resulted.

Of itself, the ability to make quick decisions is commendable rather than otherwise, and when it has a sound basis of experience, there is no objection to exercising it. However, when this ability is merely assumed, such decisions are little more than guesses which are just about as likely to be wrong as correct.

How Often Do You Pull and Clean Your Knife Switches?

THAT poor contact, with consequent high resistance, in the jaws of knife switches may be the unsuspected cause of a good deal of trouble was shown by two cases which recently came to light.

In the first instance, one leg of a 1,500-amp., three-pole service switch in a large office building suddenly melted and caused considerable annoyance until the cause of the trouble was located. Upon investigation it was found that the load was in the neighborhood of 600 amp., considerably less than the rated capacity of the switch, which it was then recalled had been heating for some time. Examination of the switch showed that the contact surfaces of the blades and jaws were black and badly pitted from small arcs. So far as could be determined this switch had not been pulled for several years, perhaps not since it was installed. Dirt and the natural tendency of copper to tarnish and corrode had in time increased the resistance of the contact surfaces until serious heating took place, which further aggravated conditions until failure occurred.

In the second case, complaints of low voltage on some of the branch circuits in another large building created a suspicion that the feeders were too small for the load carried. However, checking the size of the feeders against the load showed that there was an ample margin of safety. The trouble was eventually traced to the service switch, which was heating badly and introduced enough resistance into the circuit to cause a decided voltage drop. As in the previous case the contact surfaces were badly discolored and pitted. When the switch was cleaned and put in proper condition there was no further trouble.

The remedy for such conditions is obvious: Pull all knife switches frequently and polish the contact surfaces of both blades and jaws, making sure that the latter grip the blades firmly.

Education in Material Costs Will Help to Prevent Waste

PREVENTING waste of the materials and supplies used by the maintenance and repair departments is oftentimes a rather difficult problem. Comparatively few workmen are deliberately wasteful of the materials they use, and when one such individual is discovered a friendly word of caution may be all that is needed to bring about the needed change of habits.

The carelessness or thoughtlessness that most of us possess to a greater or less degree presents, however, a much more difficult situation. It is carelessness more than anything else that causes a workman to draw out more wire, conduit or whatnot than he needs for the job in hand and leave the excess lying around until it becomes useless, or else quietly consign it to the junk-pile, when no one is looking.

In most cases the real reason for this carelessness or indifference is a combination of ignorance of the cost of materials and failure to realize that these cost money. With a well-stocked storeroom to draw from it is easy, perhaps natural, to adopt the attitude that "there is plenty more where that came from"—an attitude that is fatal to the economical use of material.

Along the same line is the tendency of many workmen to use expensive materials, for example special wire, when cheaper, standard material would be entirely satisfactory. Individually these little wastes may not be very important, but in the course of a year their total may well be enough to increase the cost of maintenance and repair work considerably.

One of the most effective means of combating carelessness of this sort is a campaign of education in the cost of the materials and supplies used. If a workman can be taught to think of these in terms of dollars and cents per foot or per pound, they will assume a new measure of value in his eyes and he will be far less likely to waste them needlessly.

A Squirrel-Cage Motor Takes Advantage of an Easy Master

WHEN laying out an installation of equipment it is usually more economical in the long run to allow a liberal margin of reserve capacity to take care of unexpected overloads and normal growth. Not only will time and money probably be saved later on, but there is the satisfaction of knowing that the present installation will safely handle any likely demands. In the case of most items of equipment found in industrial plants, the possession of a reserve capacity even largely in excess of the present requirements is not of serious consequence. Some capital will be tied up needlessly in heavier equipment than is required, and operating losses of one sort and another may be increased, but that is about all.

Squirrel-cage motors are one of the exceptions to this general rule. This type of motor possesses many desirable features, but one of its weak points is that at loads much below rating the power factor falls off rapidly, particularly in the case of slow-speed motors. If many underloaded squirrel-cage motors are in use in an industrial plant the power factor may easily be reduced to the point where it becomes an expensive and serious problem.

Consequently, when selecting a squirrel-cage motor for a given application, it should be remembered that this type of motor operates at its maximum power factor and efficiency at somewhere near rated load. This means that the power requirements must be known, or determined as accurately as possible. Ordinarily it is not a difficult matter to determine the power required to drive a machine or lineshaft, and the time and effort involved in so doing will be well spent. Naturally, any unusual load conditions must be given due consideration, and good judgment must be used in allowing for probable overloads, but aside from this, an excess of capacity in a squirrel-cage motor should ordinarily be considered as a liability rather than an asset.

A Well-Equipped Electrical Repair Shop Will More Than Pay Its Way

DOES your electrical repair shop consist of a workbench, an armature rewinding stand, a few reels of wire, some rolls of tape, and a can of paint, or is it a small factory equipped to do rebuilding of damaged equipment? Many executives think of the repair shop as a non-producing part of the plant, and consequently slight it when obtaining shop equipment.

Three steel plants that the Editors have recently visited had repair shops that were nothing more than a miscellaneous collection of cast-off machines and junk. As a direct result, the quality of repair work has suffered and a high repair cost has been accepted by the management as an unavoidable necessity.

All three of these plants are now engaged in building modern electrical repair shops, for the electrical superintendents have at last been able to convince their superiors that these are a good investment. Only one shop visited, and which is now completed, contains complete equipment for repairing motors and control equipment and also for doing the machine work that is necessary in this connection. A partial list of the equipment in it includes coil winding equipment, two drill presses, banding lathe, standard lathe, armature press, shaper, dipping tank, modern baking oven, complete electrical storehouse, and even a ball-bearing-equipped overhead traveling crane to serve the shop alone. This shop is as completely equipped as the motor assembly floor of a small motor manufacturer.

The result is that the repaired electrical equipment will be as good as new equipment of the same type obtained from the manufacturer. It is on this basis that modern and complete repair equipment in the repair shop can be justified, and will effect a substantial return on the investment.

Annual Convention of

Association of Iron and Steel Electrical Engineers

which will be held in connection with the Iron and Steel Exposition at Chicago, Ill., June 7 to 11, 1926.

UNUSUAL efforts have been put forth to make the Twenty-second Annual Convention more interesting and a greater success than ever before.

The convention has been planned with the thought of answering the question of what are the accomplishments of the industry, keeping in mind the tendency of the times. From the program shown in the adjoining box it will be seen that the subjects covered are of direct interest to every engineer and executive in the iron and steel industry.

This year's convention will be held at the Hotel Sherman, Chicago, Ill. A new feature, and one which should help to make the convention a greater success, is that all of the convention activities will be under one roof. With the exception of the meetings of the Safety Session, all of the papers and discussions will be presented in the Crystal Room of the hotel. The exhibits of the Iron and Steel Exposition will be held in the Exposition Hall and Ballroom combined, while the social affairs will take place in the Louis XVI Room and the Bal Tabarin of the same hotel.

The Iron and Steel Exposition, more aptly termed the "Million Dollar Engineering Exposition," will be larger and better than ever before. Thirty-five thousand square feet of space will be devoted to displays of manufacturers, showing the latest developments in electrical, mechanical, combustion, and safety equipment devised for steel mill use.

This association, as its name indicates, is an organization of the electrical engineers of the iron and steel industry. In 1907 at a meeting of representative electrical and mechanical engineers to inspect a special exhibit of electrical apparatus for use in steel mills, at one of the plants of a prominent manufacturer, it was suggested that a national organization be formed to promote a closer spirit of co-operation between the engineers of the industry. Since this time rapid strides have been made in the industry, particularly in the application of electrical energy to its power problems. Due to the interchange of thought brought about by this association, electrification of the steel industry has proceeded at a more rapid and successful rate than has the electrification of any other industry. As time went on the Association broadened its activities. In 1912 it founded what is now known as the National Safety Council. At a later date when the waste of heat in steel mills became more generally recognized, a Combustion Division was formed, which was to be devoted to solving the heat and fuel problems of the industry. Last year it was felt that, in the last analysis, safety in the steel mills rested upon the degree of co-operation obtained between the safety man and the engineers who know the inherent characteristics of the machines that must be guarded. With the view of promoting co-operation between these two groups of men, the Safety Division was organized. As a result the Association's activities now enter the fields of electricity, heat, and safety, as applied to the steel mills.

The Association of Iron and Steel Electrical Engineers is the only organization devoting its attention primarily to industrial power problems, and specifically to the application of electrical energy in the iron and steel industry. **The same general problems interest and must be solved by men in all other industries and it is for this reason that INDUSTRIAL ENGINEER will report the activities of this convention for its many readers in other industries, as well as those in the steel mills. If it is at all possible we would suggest that you plan to attend this convention. You will receive a royal welcome and be afforded an opportunity of exchanging ideas with men who have met and solved many perplexing industrial problems.**

Program for Annual Convention of Association of Iron & Steel Electrical Engineers

MONDAY, JUNE 7

9:00 a.m.—**Registration**—Mezzanine Floor.

10:00 a.m.—**Business Session**—Crystal Room.

12.30 p.m.—**General Luncheon**—Louis XVI Room.

1:30 p.m.—**Safety Session—Rules for the Safe Operation of Electric Overhead Traveling Cranes.**—Louis XVI Room.

9:00 p.m.—**Informal Reception**—Louis XVI Room.

TUESDAY, JUNE 8

ELECTRIC TRANSPORTATION DAY

10:00 a.m.—Crystal Room—**Economies of Steel Plant Railroad Electrification**, by O. Needham, General Engineering Dept., and David C. Hershberger, Engineer, Railway Section, Westinghouse Electric & Mfg. Co.

How Electrical Industrial Truck and Tractor Equipment Is Effecting Savings in the Iron and Steel Industry, by H. J. Payne, Electrical Industrial Truck Department, The Society for Electrical Development.

Yard Switching and Mill Transportation, by W. P. Potter, Engineer, Railway Dept., General Electric Co., and G. H. Shapter.

WEDNESDAY, JUNE 9

10.00 a.m.—Crystal Room—**Refractories for Use in Steel Plants**, by M. C. Booze, Senior Fellow, Mellon Institute, Pittsburgh, Pa.

Open Hearth Roof Construction, by W. J. Harper, Combustion Engineer, Donner Steel Company.

Refractories in Steel Plants, by W. H. Kelly, Refractory Engineer, Bethlehem Steel Company.

Coke Ovens, by M. J. Conway, Combustion Engineer, Wheeling Steel Corporation.

Heating Furnaces, by E. W. Trexler, Combustion Engineer, Bethlehem Steel Company.

Gas Producer Operation, by F. E. Leahy, National Tube Co., Pittsburgh, Pa.

Standardized Mill-Type Motors, by A. C. Cummins, Chairman of Standardization Committee.

THURSDAY, JUNE 10

10:00 a.m.—Crystal Room—**Report of Electric Heat Committee**, by W. P. Chandler, Chairman.

Additions to Rolling Mills, Wheeling Steel Corp., Steubenville Plant, by M. J. Conway, Combustion Engineer, Wheeling Steel Corp., Steubenville, Ohio.

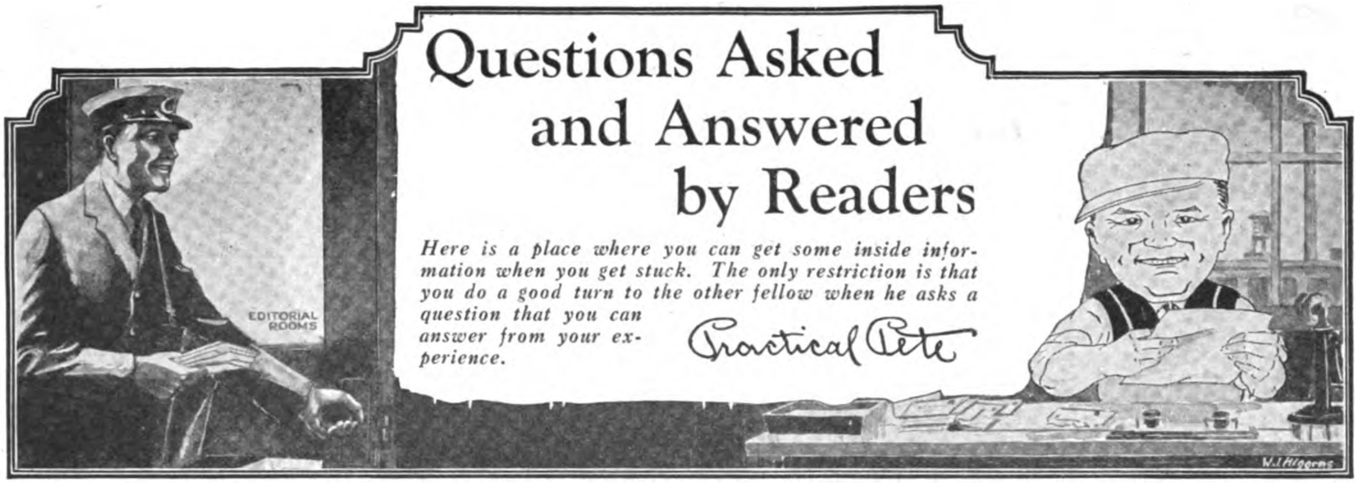
Results of Tests—Four Cylinder Poppet Valve Reversing Uniflow Engine Driving a Blooming Mill, by M. J. Conway.

7:00 p.m.—**Formal Dinner Dance**—Bal Tabarin.

FRIDAY, JUNE 11

9:00 a.m.—**Inspection Trip**—Illinois Steel Co., Gary, Ind.

1:00 p.m.—**Golf Tournament**—Gary Country Club.



Who Can Answer These?

Use of Non-Metallic Gears—I wish that our readers would give me their experience with the so-called non-metallic gears. We have several gear drives which wear rapidly, due to irregular loading, and soon become noisy. If I should use non-metallic gears would I have to use pinions with wider faces, and also have to replace the present gears with others having wider faces? If so, approximately how much wider would the faces have to be?
Des Moines, Iowa. J. F. K.

* * * *

Method of Controlling Brush-Shifting Motor—I should appreciate it very much if some reader would tell me the different and proper ways of controlling a type BTA, General Electric, adjustable-speed, brush-shifting, alternating-current motor. I should like to know what type of control should be used, and any information or explanation of the principles under which this controller works will be greatly appreciated.
Passaic, N. J. H. V.

* * * *

Charging Storage Batteries—Will some readers of these columns please inform me how, if possible, I can make up a unit to charge small storage batteries from a 220-volt, direct-current power supply? The storage batteries range from 1 cell (2 volts) to 6 cells (12 volts) in potential and up to 240 amp.-hr. in capacity. Can I charge these batteries from a lamp bank? If so, how many and what size of lamps should I use, and how should they be connected? Any other information that readers can give me along this line will be greatly appreciated.
Chicago, Ill. W. A. B.

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Why Do These Motors Stall?—The motors on two Yale and Towne electric hoists are giving us trouble and I wish someone would tell me how to remedy it. One hoist is of 1-ton capacity and is driven by a 220-volt, three-phase, 60-cycle, six-pole motor. The other hoist is of ½-ton capacity and is also driven by a three-phase, 220-volt, 60-cycle motor. If a load of 200 lb. or more is placed on the hooks the motors will stall, although they seem to run at full speed at no load. This trouble started suddenly. The mechanical part of the hoists has been inspected and appears to be in good condition. Your suggestions will be very welcome.
Iola, Kan. T. R. P.

* * * *

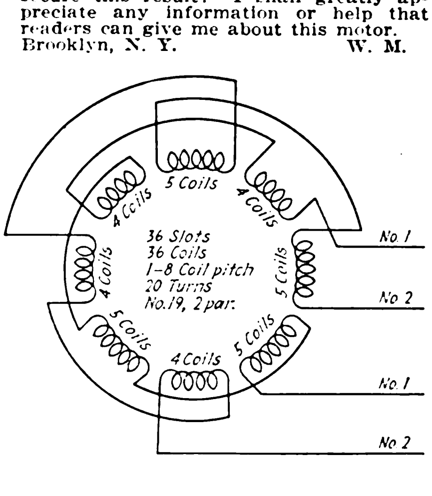
Excessive Wear on Brake Wheels—We use magnet-operated, shoe-type brakes on many of our steel mill auxiliary drives such as manipulators, side guards, screw-downs, crane hoists, and the like. There is excessive wear on the brake wheels and I should like to know how other readers have corrected this trouble. The brake shoes pressing against the wheel are lined with "Thermoid" or similar brake lining and the wheels are machined from 0.20 per cent carbon steel; yet the wheels show distinct grooves and ridging in less than 6 mos. service. Should harder steel be used, or will heat-treating the brake wheels be of benefit? I should like to learn the experience of readers in regard to the latter.
South Chicago, Illinois. W. A. F.

* * * *

Correcting Power Factor—We are planning to electrify the drives in our planing mill, which will require about 600-hp. in 440-volt induction motors, and I estimate that our power factor under average conditions in this mill will be about 70 per cent lagging. I have a 440-kva., 595-amp. 440-volt synchronous motor which I plan to use on a fan in the planing mill that will require about 150 hp. to drive it. This is in addition to the 600-hp. load previously mentioned. I should like to know how much improvement in power factor I can obtain by over-exciting this synchronous motor when it is connected to the same feeder as the rest of the planing mill load and while it is driving the 150-hp. load. I must have a power factor of at least 90 per cent lagging on this feeder and any additional improvement that I can obtain will be very welcome. Can some reader calculate for me or tell me how to determine the resultant power factor if I use the synchronous motor as I have explained above? I should also like to obtain the views of readers as to whether it would be better to use static condensers instead of the synchronous motor for correcting the power factor in this mill.
Bellingham, Wash. E. M. D.

* * * *

Changing Single-Phase Motor for Three-Phase Operation—I have a General Electric, form C, 60-cycle, 220-volt, 1-hp., single-phase, 1,800-r.p.m., motor connected as shown in the accompanying diagram. The armature has 36 slots, and 36 coils, having 20 turns of No. 19 wire wound two in parallel. The coils are arranged in groups of 4 and 5 coils per group as shown. (1) How should this winding be connected for use on a single-phase supply? (2) It is desired to connect the motor and operate it from a three-phase supply. Is it possible to change or reconnect the winding to secure this result? I shall greatly appreciate any information or help that readers can give me about this motor.
Brooklyn, N. Y. W. M.



Answers Received To Questions Asked

What Are the Comparative Advantages of Two-Point and Four-Point Adjustable Hangers?—I am planning on installing an additional section of lineshaft and would like to get the opinions of other readers about whether to use two-point or four-point adjustable hangers. What are the advantages of each from the installation, operation, and maintenance standpoints? Would these advantages be worth the difference in cost? This will be a 1{15/16}-in. shaft, 50 ft. long. The present installations are all two-point adjustable hangers. Will other readers tell me what they would use and why?
Indianapolis, Ind. B. K. W.

In response to B. K. W.'s inquiry, I believe that the four-point adjustable hangers are generally accepted as the most desirable. The ease of making minute adjustments, vertically and horizontally, by means of the adjusting screws, is a material advantage from the installation point of view. Also, in case of warpage, shrinkage, or yielding of the structure to which the hangers are fastened, the bearing proper can usually be adjusted without disturbing the mounting of the hanger proper.

The boxes with bearings on all four-point hangers are designed for easy removal, which is an advantage should it become necessary to replace a worn bearing. I would use the four-point adjustable bearing hangers for the following reasons: (1) Saving in time in the initial installation. (2) It is comparatively easy to align the shaft. (3) It is comparatively easy to correct misalignment due to yielding of hangers, supports, and so on. (4) Bearing boxes are readily replaceable. E. H. LAABS.
Engineer,
The Cutler-Hammer Mfg. Co.
Milwaukee, Wisconsin.

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Regarding B. K. W.'s question, the writer would say that in his experience the four-point hanger is practically always preferable to the two-point hanger for line- and countershafting. Nearly all hangers have slots or elongated holes in their feet which allow them to be adjusted sidewise or perpendicularly to the line of the shaft. Setscrews are also provided in the hanger frames for vertical adjustment of the boxes in which the shaft revolves.

The four-point hanger has setscrews in each side of the frame in addition to the top and bottom setscrews; in this way adjustment of the box within the

frame is provided in both directions. With the two-point hanger, where the setscrews provide vertical adjustment only of the box, the lateral adjustment is secured by loosening the nuts on the bolts in the hanger feet and shifting the entire frame in the required direction. Obviously it is much less troublesome to secure the lateral adjustment by means of the setscrews in the frame. When the nuts on the bolts in the feet of the frame are removed, there is for the moment no support for the shaft at that point and it has to be supported while the entire hanger frame is shifted.

It might interest B. K. W. to know that standard steel sections can now be secured for supporting shaft hangers. These sections, used in the same way that wooden stringers have been used, allow any required amount of lateral adjustment for the hangers. In other words, the hanger can be slid along the steel section by means of a sliding bolt seat. These sections are clipped into place in wood, steel or concrete buildings and no holes have to be provided for the feet of the hangers.

Vice-President, P. L. PRYIBIL.
Midwest Steel & Supply Co., Inc.,
New York, N. Y.

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Changing Slip-Ring Motor to Squirrel-Cage Type.—I wish to change the rotor of a wound-rotor induction motor so that it will operate as a squirrel-cage motor. I have rewound the stator for 900 r.p.m. instead of 600 r.p.m. as originally. I have removed the clips from the rotor winding and have the coils ready to short-circuit on themselves. Will it be necessary to change the rotor coil span in order to make the motor operate efficiently? Should I put a ring at each end of the rotor and connect all of the rotor conductors to it, thereby making the winding quite similar to a squirrel-cage winding? Is there a quicker or better way than I have mentioned for converting the wound-rotor winding into a squirrel-cage winding? I would like to obtain the opinion of other readers as to the advisability of making this change in the winding.
Bessemer, Ala. O. S.

The data given do not state whether the rotor is wave or lap wound; however the following discussion will cover either case. If the rotor winding is of the wave-wound type, short-circuit the rings; or if rings are to be removed, short the three leads from the winding, making a permanent connection. Do not disturb the present connections of the individual coils; that is, leave the winding as it was for 600 r.p.m. Then remove the insulation from the top layer of leads for a distance of approximately 2 in. back of the clips. A *bronze* wire band (No. 10 B. & S. gage) is then run over the copper leads thus exposed. This band should be soldered to the leads which it covers, with a tin solder, not half-and-half solder. The points where the connections are made to bottom leads for star leads, or reversing jumpers, should be connected to the top clips.

The object of the bronze wire band is to connect the top and bottom leads together, thus shorting all coils. This is the quickest way of arriving at this result. However, if O. S. has all the clips removed and the leads bent in towards the center of the coil it will be satisfactory to short each coil on itself. The coil pitch in this case will be satisfactory.

It will not be necessary to connect a ring to the ends of the coils; neither will it be necessary to cut open the rear of the coils, nor to add a ring to the rear of the coils.

The motor with the rotor connected in this manner will have low starting torque and will require the use of the high-voltage tap of the starting compensator.

Wilkinsburg, Pa. A. C. ROE.

* * * *

Trouble with Solder.—We are having considerable trouble in making soldered joints hold on rectangular wire in coils that are subjected to rather high temperature, such as might be the case in series field coils and brake series coils. We have tried an 80 lead—20 tin solder, but it melts due to the excessive heat. Can our readers suggest any methods that will enable us to join these wires together in a manner that will stand rather high temperature? I shall be very much indebted to any reader who can give me some help in this matter.
Norton, Va. W. H.

In regard to W. H.'s question, I believe he will find brazing the best process for connecting two ends of wires together for use where there is excessive heat. Take a piece of hard carbon and file a slot large enough to take the size of wire to be used. Clean the wire thoroughly and space the ends ¼ in. apart in the carbon slot. A welding torch with the smallest tip available is best for welding so small a joint, but a gasoline blow torch can be used if it throws a large flame.

When the joint is at a good red heat apply Brazo fluz which is manufactured by the Oxweld Acetylene Co., Long Island City, N. Y. After applying this flux very freely, add enough spelter, a brass alloy, to fill the ¼-in. gap between the wires and hold the torch flame on this joint until the spelter runs freely. Allow the soldered ends to cool slowly in the air but do not apply water as it will make the brazed joint brittle.

Where a joint of this type is used in a coil try and cut the wire so it will not make a bend at the joint. After the joint has cooled file it down to the size of the wire. From my experience a splice of this kind has always made an ideal connection. C. L. PHELPS.

Electrical Dept.
Illinois Central Railroad Co.,
Centralia, Ill.

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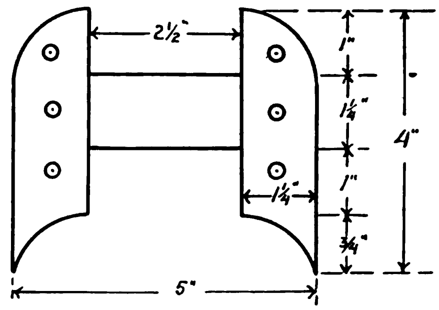
Referring to W. H.'s question, the melting point of an 80 lead—20 tin solder is high enough for most purposes. It seems to me that something else must be wrong to melt this composition of solder which has such a high melting point, unless the solder has not been applied correctly.

The joining together of such connections is best accomplished by riveting, if conditions make it possible. In any event binding wire can be used on the splice for mechanical strength and good soldering. The wires might be silver soldered if it is possible to secure the necessary heat to do the job properly. However, if the machine were mine, I would investigate the conditions that cause a temperature high enough to melt solder. E. J. MORRISSEY.

Chief Electrician,
Western United Gas & Electric Co.,
Aurora, Ill.

Winding Data for Growler.—I wish to build a growler of the dimensions shown in the accompanying diagram, for use in testing armatures in our shop. It is my intention to wind this growler with No. 12 double-cotton-covered magnet



wire and I wish some reader would tell me the number of turns of wire to use and also the depth of laminations required. I want to use this growler on 110-volt alternating current. Any information that readers can give me about making up this growler will be greatly appreciated. J. M. M.
Hattiesburg, Miss.

In reply to the question by J. M. M. regarding the size of wire and number of turns to use on a growler for armature testing, the following may be useful.

The dimensions of the growler which I recommend are nearly twice the size of the one specified by J. M. M., but the principle of operation is the same. The width 5 in. should be 9 in.; the thickness of the core, 1¼ in., should be 2¼ in.; the coil space of 2½ in. should be 4 in.; the height, 4 in., should be 7 in.; and the length, not given, should be 6 in.

This growler is wound with 60 turns of No. 6 d.c.c. magnet wire. I think if J. M. M. will stack the laminations about 4 in. thick and use 100 to 120 turns of No. 12 d.c.c. wire, he will obtain satisfactory results. An excellent book recently written covering this subject and many other handy repair shop "kinks" is entitled, "Rewinding Small Motors," by Braymer and Roe.

Chief Electrician, LEE F. DANN.
Donnacona Paper Co., Ltd.,
Donnacona, Que., Can.

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In reply to J. M. M.'s question, I would suggest that he use a larger core than the one shown in his diagram. Instead of the width of 5 in., I would recommend using a width of 10½ in.; make the height 7½ in., and the thickness of the polepieces 1¼ in. The dimension of 2½ in. shown on his sketch will then become 4½ in. and the length of the core, which is not given, should be 5 in.

This core should be built of thin sheets of iron and held together by ¼-in. brass plates and brass bolts. The bolts in these plates should be countersunk and riveted over after the plates have been tightly drawn together by a clamp or vise. The core laminations can be drawn up tightly by bolts in four of the five holes which are equally spaced; the clamp may be applied near the fifth hole when putting in the first rivet. Then the bolts may be taken out one at a time when putting in the other rivets.

This core should be wound with 180 turns of No. 10 d.c.c. magnet wire for 60-cycle, 220-volt service; for 60-cycle, 110-volt service use 90 turns of No. 7

B. & S. gage, d.c.c. magnet wire. I would advise J. M. M. not to wind this coil with No. 12 wire, as it will prove to be too small to obtain good results.

HARRY J. ACHEE.

Chief City Electrician,
Woodward, Okla.

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In reply to J. M. M., judging from the size of iron specified and voltage, I assume that this growler is to be used only on small armatures.

I have a growler approximately the same size as the one which J. M. M. shows in his sketch. The only difference is that the height is 5 in. instead of 4 in. and the thickness is 1½ in. instead of 1¼ in. This growler has 160 turns of No. 15 wire and is used on 220 volts. The coil is wound in two sections in order to adapt it for operation on either 110 or 220 volts. At times the two coils are used in parallel on 220 volts, if it is desired to heat a coil up quickly.

If J. M. M. will wind his growler with 70 turns of No. 12 wire, I am sure it will be found quite satisfactory for general use. When using a winding that contains larger wire and less turns, it will be found that when testing armatures having fine wire, the induced current may be heavy enough to burn the armature winding open before the short can be located.

I also have a larger growler wound with two coils, one on each leg, each wound with 50 turns of two No. 6 wires in hand or a total of 100 turns. The dimensions of this growler are 12 in. in width, corresponding to the 5 in. on the diagram of J. M. M., and 12 in. in height instead of 4 in., with a thickness of 4 in., instead of the 1¼ in. shown. When this winding is used across 220 volts to test a 5-hp. armature, it draws 102 amp. from the line. The larger the armature under test, the smaller the amount of current taken from the line.

NICHOLAS J. WEISS.

West New York, N. J.

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Is Hard-Drawn or Cast Copper the Better Material for Commutators?—I would like to find out the difference in operating characteristics, if any, between commutators made from hard-drawn copper and from cast copper. In the advertising literature of many of the large manufacturers of motors and generators, commutators are frequently described as being made of hard-drawn copper. Some repair shops furnish commutators made from cast copper. Which material wears the longer? Which material will polish better under the brushes? Does the sand in the cast copper cause eating away of the mica segments between the bars? Would the use of cast copper segments cause excessive heating of a generator or motor? I shall appreciate any information or comments that readers can give me regarding their experience with either type of material.

Cleveland Heights, Ohio. C. B. K.

Replying to the question by C. B. K., asking whether hard drawn copper or cast copper is the better material to use for commutators, I would say that a few years ago I had charge of a small, direct-current generating station in which the commutators were made of cast copper. These commutators were a continual source of trouble, as there were soft and hard places in them which resulted in very uneven wear. By the time the harder side obtained a polish, the softer side would be worn down to the mica, which resulted in having to turn down the commutators about once a month.

I do not know whether the sand in the copper was the cause of mica pitting, but we had to clean out between the bars every day or so. These cast copper commutators were replaced with some made from hard-drawn copper, which are now giving perfect satisfaction.

PHILIP M. EMIGH.

Chief Engineer,
Mountain Water Supply Co.,
Indian Creek, Pa.

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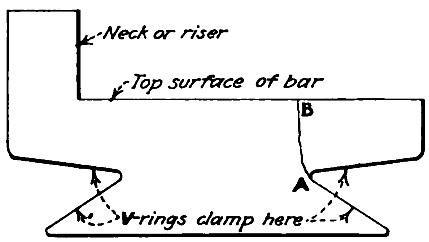
Replying to the question by C. B. K., I want to say that my experience over a period of 25 years has proved to me that the best material is the cheapest in the long run. The following statements are made from a careful investigation of commutator material.

There is only one thing that can be truthfully said in favor of a cast-copper commutator, and that is, the price



Cast copper segments are subject to breakage at points A-B.

is cheaper than for a hard-drawn copper bar commutator, especially where the commutator has a high solid riser. A cast-copper commutator will not take on as good a polish as the hard-drawn commutator, will not wear as long, and will "pit" more. Use of cast copper segments causes the mica segments to be eaten away sooner and in many cases will break at the points *A-B* as shown in the accompanying diagram. If the armature has to be rewound, a cast bar with a solid-type riser will break off at the projections next to the wires in the commutator slot more often than a hard-drawn bar.

Norton, Va. WILLIAM HANKS.

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Replying to C. B. K.'s question as to the comparative qualities of cast and hard-drawn copper commutator bars, I would say from my own experience with both, that the hard-drawn material is more satisfactory. Uniformity of material throughout the bar is a necessity and with cast copper this quality is hard to obtain. The hard-drawn bar, on the other hand, is inherently the same all the way through and without holes or spongy spots.

The correct bevel or taper of the sides of the bar is hard to obtain with castings, but the use of dies or rolls for producing the hard-drawn bars makes it easy to hold this shape to close limits and facilitates the assembly of the bars in the commutator.

In regard to heating, there is little difference between the two bars, unless the cast bar shows sand or shrink holes at the brush contact surface. In this event, the contact area being decreased heating of the brushes and commutator will occur unless the proportions of both are liberal.

Both materials polish about equally well under proper commutating conditions and both wear evenly unless a spongy section shows up in some part of the cast bar. This possibility is always present with cast bars and when through wear a sand hole or a spongy part is exposed on the contact surface, trouble begins. If a defective spot occurs near the edge of a bar, the mica may break down due to the accumulation of carbon dust and grease in the sand hole.

Drop-forged bars come nearer to the hard-drawn material in desirability than do the ordinary cast bars. However, the tool charge on these is much higher than on the hard-drawn bar, so that for the repair shop, at least, the hard-drawn bar has another advantage. The tool charge on hard-drawn bars was formerly very high and this gave the cast bar a decided advantage, but with improved methods, this handicap has been removed and the cast bar has practically no quality to recommend its use.

Ass't. Chief Engineer, J. M. WALSH.
Guerney Elevator Co.,
New York, N. Y.

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In reply to C. B. K.'s question, he will find drop-forged copper the best to use for making commutators. Commutators are made of three different grades of copper: that is, drop-forged, cold-rolled and cast. Cast copper is of very low grade and is likely to be porous, which makes it difficult to polish so as to obtain a good smooth surface. Its wearing qualities are from 75 to 90 per cent of those of hard-drawn copper. Cast copper should be used only when hard-drawn copper is not available. Hard-drawn copper is the longest wearing and will also polish better, therefore, cutting down brush expense.

I do not find that sand in cast copper has any effect on the mica. It has been proven that the pores in cast copper fill with carbon dust off the brushes and cause heating. If the pores are close to the mica, this heating breaks down the mica and causes trouble.

Electrical Dept., C. J. PHELPS.
Illinois Central Railroad,
Centralia, Ill.

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In reply to C. B. K.'s question, it has been my experience that the operating man who pays attention to the advice of the manufacturer has the least trouble and expense. The manufacturer's organization and integrity are founded on years of experience and at a considerable cost in trying to put out the best product possible; so when the manufacturer advises the use of good copper for commutators, he speaks from a background of experience in manufacturing and repairing them.

Rolled copper has all of the good advantages in comparison with cast copper. Cast copper has about 80 per cent of the conductivity of rolled copper and will not wear as long. Cast copper also has impurities, blowholes and other defects that may be minute enough to be invisible but are detrimental to the commutator. I would not blame the eating away of mica directly to the sand, as it is more likely due to

the poor conductivity of the cast copper. This poor conductivity is the equivalent of overloading a commutator and causing heating, sparking and other troubles. When one considers that cast copper has 20 per cent less conductivity, the heating becomes quite an item, particularly when a commutator is designed closely. Good commutation cannot be expected from a poorly-designed commutator or one repaired with inferior material. Accordingly, I would strongly advise using the highest grade of copper, which should be put together in the best possible manner and should have extremely good care in operation, because a commutator costs money to repair. E. J. MORRISSEY.

Chief Electrician,
Western United Gas & Electric Co.,
Aurora, Ill.

* * * *

In reply to C. B. K.'s question, asking whether it is better to use cast or hard-drawn copper for commutator segments, I would say from my experience that hard-drawn copper is superior in many ways. It has less impurities than cast copper and consequently has a lower resistance, which results in less heating. I never have seen a cast commutator that could compare with a hard-drawn commutator in regard to polish and color after it had seen six months of service.

We have obtained commutators from four different manufacturers and, with the exception of one, they all make cast bars because they are cheaper. The repair shop is after the cheapest material to meet competition. This is the only logical reason for using it, according to my opinion.

Another point I have against cast copper commutators is that very often blow-holes are found after machining them in the lathe. When an assembled commutator is bored out, the end chips will invariably dig into the mica. It is then necessary to obtain a pick and dig them all out. If one chip should push its way out of sight, there will be a short-circuit when the commutator is heated and pressed together.

I might add that if the commutator is of ample size the heating will be of little consequence. I do not think that enough sand will be found in cast bars to cause any trouble in the way of short-circuits. NICHOLAS J. WEISS.

West Newark, N. J.

* * * *

Selecting Belts for Oily Work.—We have had considerable trouble with the drives in the screw machine department of our plant due to the belts getting soaked with oil. We have been using leather belts. I would like to know whether there is any treatment I can give these belts to make them oilproof or if there is any belt which is not affected by the oil. Also, how do other men with a similar problem remove the oil from the used belts and put them in condition for service again?

Chicago, Ill. G. F. H.

In line with my experience, G. F. H. may obtain good results if he will remove the oily belt from the machine, and first scrape off all of the oil and dirt that he can and then wash the belt thoroughly in gasoline until all oil is removed. He should not soak the belt too long unless he has facilities for recementing any joints or laps which may be loosened by the gasoline.

After the belts are dry and free from gasoline he should apply two coats of castor oil with a brush on the pulley side of the belt; after most of the castor oil is absorbed the belt is ready for service.

I do not know of any oilproof treatment for belts. From my experience, leather belts give the best service for a drive of this kind, with the exception of a chain drive on direct-connected screw-machines.

Marietta, Ohio. E. L. WAY.

* * * *

There is to my knowledge no belt made which will stand up and give anything like efficient and continued service under the oily conditions too often found on screw machine work. Naturally, the more the belts can be protected from the oil spray the better the service that can be secured. As it is impossible to keep oil entirely *off* from these belts, the only thing to do is to keep it *out* of the belts, because leather belts are without question the best for this service. I would suggest that you thoroughly fill the belt with a belt dressing of heavy density. The belt cannot thereafter absorb much oil because it will already have absorbed its fill of a preservative material heavier than the oil and which the oil will not displace from the fibers of the belt. By wiping the surface oil off the belt day by day and applying a little belt dressing, good results can be secured.

To remove the oil with which the belt is saturated, the belt can be immersed in gasoline for 48 hr. and then hung up to dry, or in place of the gasoline a non-flammable belt cleaner, such as made by belt dressing manufacturers, can be used. WM. D. YOUNG.

Cling Surface Company,
Buffalo, N. Y.

* * * *

Armature Bands Overheat.—Five bands are used on a 220-volt, d. c. armature with which we are having trouble. The armature coils slope very sharply and to prevent the outside bands from slipping off the ends of the armature, the winder soldered copper strips across the bands so as to tie them together. Six ⅜-in. strips were placed parallel to the coils and spaced at equal distances around the armature. The bands as well as the copper strips are well insulated from the armature winding, but the bands and particularly the copper strips become very hot, presumably from some induced current. I would like to know what causes this heating and how it may be prevented. If it is induced current that causes the heating please explain what causes this current. Is there any way in which I can tie these bands together that will not cause the heating referred to?

Oelwein, Ia. L. T. M.

L. T. M. asks in a recent issue for an explanation of the heating of armature bands and tie strips. The writer encountered this trouble some time ago when one of our armature winders did the same thing that L. T. M. describes.

The heating is caused by current which is generated in the copper strips, not in the bands. The strips, being parallel to the coils, will cut the magnetic field in the same way that the armature coils cut the flux. This cutting of flux generates an electromotive force in the strips, and since the strips are soldered at each end to the bands, the electromotive force or voltage causes a current to flow through the strip to one band and along the band to the next strip, back to the other band, and along it to the first strip. This is a closed path of low resistance and the current set up may be comparatively large.

It may not be necessary to tell L. T. M. that bands should not be put on a sloping surface where they are liable to slip off. But if it is necessary in this particular case to use tie strips, the trouble could be overcome by insulating the strips from the bands with mica, in order to prevent the flow of current.

Another method would be to place the tie strips in such a way that there would be an equal number of strips under similar field poles and no strips under the poles of opposite polarity. By this means electromotive forces of equal value would oppose each other and no current would flow.

R. B. TURNER.

Manager and Electrical Engineer,
Johnson-Turner Elect. Repair & Eng. Co.,
Walkerville, Ontario, Can.

* * * *

Answering the question by L. T. M., I have had the same experience that he described. His armature has five bands, two of which are not on the core and three which are core bands. Six anchor strips are provided to prevent sliding of the end bands. The heating is caused by induced current in which the anchor strips form the circuit.

This may be corrected by cutting off all six of the anchor strips on each side of the center core band, leaving the one core band on each side to support the end bands.

In my case I had four of these anchor strips, each being of different width. After running the motor for three minutes, the strips smoked, and the smallest one fused apart. After cutting all the anchor strips open on each side of the center band the bands were all right. I hope this procedure will cure the trouble in your case, also.

Chicago, Ill. CHARLES REICHENBACH.

* * * *

Replying to the question of L. T. M. in reference to armature band heating, the method of connecting the bands that is used by L. T. M. gives a short-circuited winding revolving in a field and will cause heating for the same reason that a short-circuited coil in the armature will heat, the difference being only in degree. There is a field due to leakage, much weaker than the field in the air gap, in which the copper strips are rotating and cutting the flux. This sets up an alternating electromotive-force in the strips, and the bands complete the short-circuit.

To prevent such heating, the strips must be so insulated that current cannot pass through them from one band to the other. L. T. M. could prevent the heating if he substituted for the copper strips some insulating material such as cord, tape or canvas. The band itself does not generate a voltage in the direction of rotation, but it does generate an alternating voltage in the direction of the shaft; hence its width should not be excessive or it will heat itself, just as the present arrangement heats. E. D. CARTER.

Engineer,
The Baylis Co.,
Bloomfield, N. J.

Electrical Service

around the works

For this section short articles describing ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing, and emergency or special installations.

Removing Overload From Motors Increased Production

IN SOME plants, motors are overloaded to increase production, but the reverse procedure will frequently obtain the same results, as was the case in a plant making armor-plate sections for battle tanks during the war.

The hard, carbon-steel plates, after being cut to the required size and angle by acetylene torches, were ground smooth at the edges on automatic planer knife grinders. The plates were bolted to a carriage on the machine which oscillated them back and forth across the edge of a 36-in. by 2-in. emery wheel. An automatic feed, which was set by adjustment to suit the size and type of plate, moved the material into the wheel as the grinding proceeded.

Each grinder was individually driven by a 5-hp., 1,750-r.p.m., three-phase, 220-volt, squirrel-cage induction motor mounted on the machine, through a belt drive on pulleys with 3-ft. centers. This alone was very poor design, since the belt had to be kept very tight to prevent slippage. A chain or link belt drive should have been used to obtain good results, as the belt tension alone, driving the 36-in. emery wheel at 900 r.p.m. was a good load on the motor. Considerable trouble was encountered with the motors running hot and sluggish, although the electrician in charge could find nothing abnormal, electrically or mechanically. The starting compensators were carefully examined and tested, but it was soon proved that they were not the cause of the trouble. All of the motors were acting similarly, which brought up the subject of low voltage, or poor power factor, but tests proved that these were normal.

At the time, I was in charge of erecting some new boards and lines in the plant for a construction company. Upon the resignation of the chief electrician, I accepted the position and set out to clear up the trouble. A close survey of the machines showed that the plates were being fed into the wheels too fast, and that a larger cut was being taken, to speed up production, than the grinders could handle. Further examination showed that the emery wheels were not being trimmed oftener than once every few days; in fact, a trimmer was difficult to find. The most troublesome machine was used for experimenting in search of the trouble.

To remove the overload, the grinding wheel was trimmed, the feed reduced to normal and the belt tension decreased. As a result, more plates were ground in less time than formerly and the motor cooled off while running all day without a stop. By testing this machine for a few days, it was found best to trim the wheel slightly after three large plates or five of the smaller plates had been ground. Trimming of the wheels and a slower feed were then started on all of the machines, which increased production from 1 to 3 plates per machine per day, and the motor trouble ended.

Overloading a machine is seldom, if ever, an economical method of increasing production. CARL G. HOWARD.

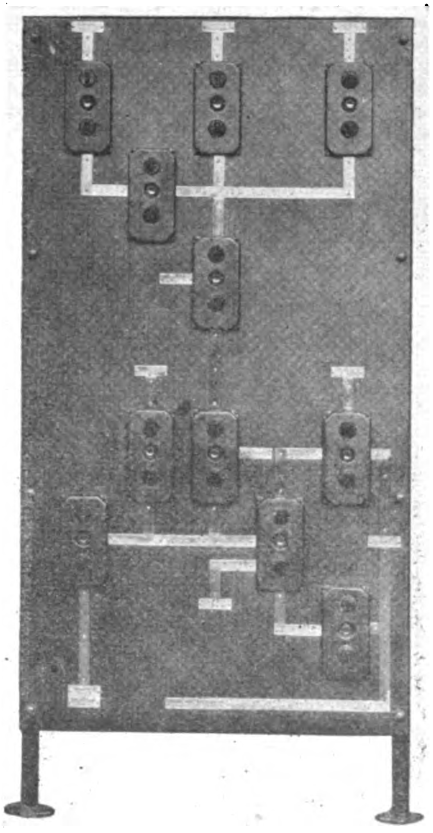
Chicago, Ill.

Panel for Remote Control of Steam Lines

A NOVEL control panel for the remote control of several high- and low-pressure steam lines is shown in the illustration. This panel was designed by the General Electric Co., for the Chapman Valve Co.

The imitation buses represent steam lines, which are identified by the nameplates.

Red indicating lamps above and below each push button show which valves are open.



The imitation buses on the panel are made of polished copper, and represent steam lines. The nameplates are engraved with the size of pipe to a particular boiler, size of pipe to a certain turbine unit, or the location of the valves. The push-button stations are used only to close valves, each being in parallel with the closing button of another push-button station located at some distance from this panel. The "open" control is located at the remote push-button station. As will be noted from the illustration, a red indicating light is placed above and below each push button.

In the lower right-hand corner of the panel there are three push-button stations. The upper button controls the valve on a high-pressure steam line feeding a unit; the lowest button controls the valve on a low-pressure steam line to the same unit, while the middle button is a master which can close either of the other two valves. As the two valves in question are on steam lines of different pressure, both cannot be open at the same time; one must always be closed. The master push-button, when depressed, will close the open valve, no matter which one it is.

By noting which of the red indicating lamps are lighted, it is possible to trace any open steam lines from the boiler to the turbine unit.

Motor Grounded by Carelessness in Reversing Rotor

SOME months ago, I was called to a small commercial establishment to find out why a motor was smoking. After operating the motor a few minutes, it began to warm up and had to be shut down. The bearings were tried by prying on the shaft with a screw driver inserted in the bearing opening of the end bell. The bearings checked all right; so the rotor was then examined, but it did not show any opens or become warm like the stator. I then asked one of the workmen nearby if any one had worked on the motor recently; he replied that the millwright had changed the pulley to the opposite end of the motor, by reversing the rotor and end bells.

This proved to be the information needed, because the rear end bell was not designed to fit the front end, which was arranged so that the frame projected further from the stator laminations. Accordingly, when the rear end bell was changed to the front where the winding connections and stubs were, it

was too short. This caused the stubs of several coils to be shorted, and also grounded because the motor frame was grounded.

In order to clear up the trouble, the damaged coils were repaired, after which the stubs were bent in toward the rotor all the way around the stator and a $\frac{3}{32}$-in. fiber ring was cut and placed over the end of the winding.

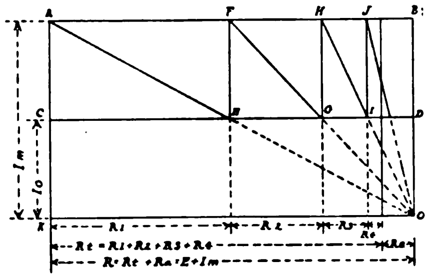
This motor was a 5-hp., three-phase machine of old design. Practically no recently designed motors have these peculiarities. However, this trouble calls attention to the fact that if any changes are contemplated in motor arrangement or if any simple motor troubles occur, it is best to call in the electrician.

Birmingham, Ala. GRADY H. EMERSON.

Graphic Method of Computing Starting Resistance for D. C. Motors

IN DETERMINING the amount of starting resistance required on each step of the starting rheostat, a convenient and simple graphical method such as described in the accompanying diagram will be found very useful.

The maximum current which should flow on the first step of the starter



Use of a diagram like this will simplify the work of calculating the starting resistance for d.c. motors

should be only sufficient to start the motor. If the starting current is over 20 amp., the first step should allow 20 amp. to flow, the second 40 amp. and so on until the motor starts. Thereafter, the back emf. of the machine gradually increases and the necessary series resistance is decreased. A gradual cutting out of starting resistance is required to attain perfectly uniform acceleration. This is possible with liquid starters, but with wire rheostats, the number of contacts is limited between the range of 6 to 12 for small and medium sizes. The resistance between each contact is chosen so that on moving from one contact to the next one, the current does not rise above a predetermined limit depending upon the design and construction of the motor.

The armature resistance R_a can always be measured according to Ohm's law, $I = E \div R$. Substituting the maximum allowable current for starting I_m for I, one can compute the total resistance R of the circuit, which is equal to the armature resistance R_a plus the rheostat resistance R_t. The total amount of resistance necessary in the rheostat will be $R_t = R - R_a$.

The graphical layout is made as follows: R_a and R_t are measured according to a convenient scale on the horizontal axis KO, I_m and I_o, the maximum and minimum allowable starting current respectively, are represented similarly on the vertical axis. The current which would have to be uniformly maintained to get the desired uniform acceleration would be $(I_m + I_o) \div 2$. Draw the rectangles $KODC$ and $CDBA$ as shown. Draw the diagonal OA, and from the point of intersection E on line CD, drop EF perpendicular to AB. Draw line OF and from the intersection point G drop GH perpendicular to AB, and so on. The perpendiculars extended in each case intersect line KO and give the amount of resistance, R_1, R_2, R_3, R_4, that should be inserted between starter contacts. *1* and *2*, *2* and *3*, *3* and *4*, and so on, according to the scale previously chosen. These values are also proportional to the time that the rheostat arm should be held on the respective contacts. The potential difference between adjacent contacts should never exceed 30 to 35 volts.

PIERRE VAN HERK.
Bressoux, Liege, Belgium.

Drum Controller for Slip-Ring Motor Rearranged for Squirrel-Cage Motor

IN MAKING some changes at our plant it was necessary to install a squirrel-cage motor for which we did not have a controller or starter. In looking through our spare equipment a drum controller for a wound-rotor, induction motor was found, which we thought would be suitable, provided we could change it from the secondary-resistance type to the primary-resistance type. The manner in which this was done is interesting.

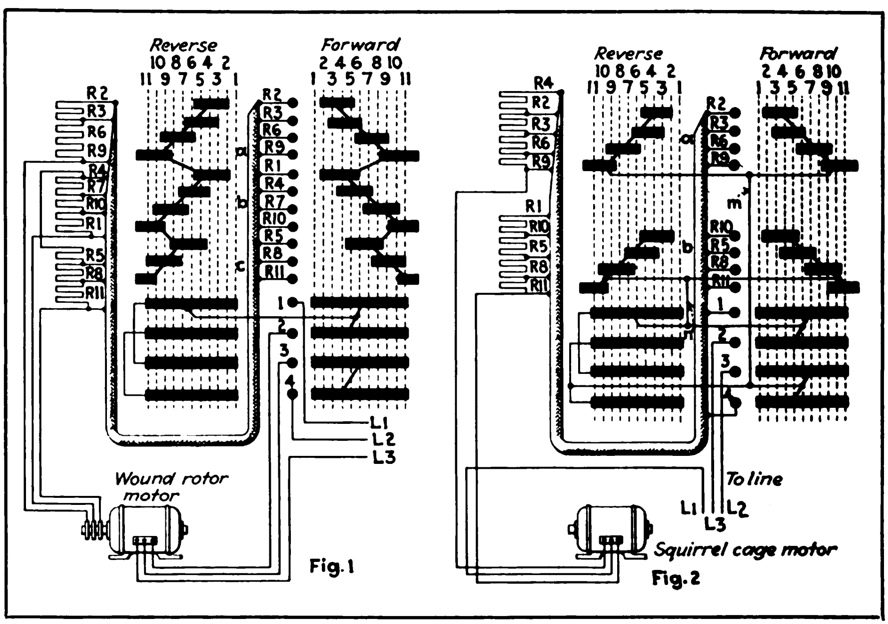
Fig. 1 in the accompanying diagram shows the arrangement of the original controller, with three sections *a*, *b*, *c* of the short-circuiting segments; these sections are cast in two halves and split vertically. In changing the controller we arranged it as shown in Fig 2. It will be seen that section *c* has been removed and sections *a* and *b* separated by cutting the casting. Sections *a* and *b* are insulated from each other by mica or fiber washers and connected to the reversing segments by the leads *m* and *n*, as shown.

This arrangement put the resistance in the stator side of the motor circuit and thus made the controller suitable for primary-resistance starting of the squirrel-cage motor. It will be noticed that line L_1 in Fig. 2 is not opened with the controller in the "off" position; therefore, the motor has one line lead always connected to the supply. A line switch should be provided to disconnect the power supply from the controller, or two additional segments and fingers could be added to the controller so that line L_1 could be disconnected when the controller is in the "off" position.

W. L. STEVENS.
Westminster, B. C., Can.

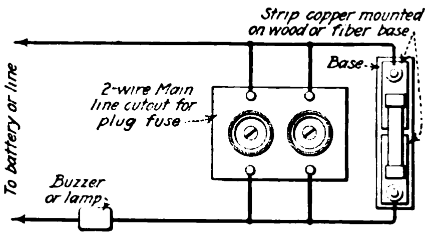
The connections of the controller were changed as shown below.

Fig. 1 shows the original connections of the controller. For use with a squirrel-cage motor, the connections were altered as indicated in Fig. 2.



Simple Testing Block for Plug and Cartridge Fuses

WHEREVER fuses are used in any quantity some convenient, yet inexpensive, device is needed for testing them out. Otherwise, considerable time



A two-wire cutout is connected across a source of supply, for testing plug fuses.

Cartridge fuses are tested by touching the ends to two copper strips mounted on a fiber base. A lamp or buzzer may be used as an indicator.

can be wasted and much inconvenience caused by trying out several fuses in a circuit before one is found that is

suitable for use. Oftentimes carelessness in replacing bad fuses with some that have not been tested is responsible for a hurry-up call for an electrician.

The fuse-testing block shown in the accompanying sketch is very simple to make. It consists of a two-wire main line cutout for testing plug fuses, the screw shells being slit down the sides so that the fuses can be slipped in easily, and two strips of copper mounted on a fiber strip of the size required for testing cartridge fuses. A buzzer or lamp is connected in the circuit as shown to indicate whether or not a fuse is blown. The source of current supply is connected to the binding posts.

This device mounted on a test board within handy reach will be found very useful and satisfactory.

NATHANIEL W. BLANCHARD.
Inwood, Long Island, N. Y.

Handy System for Keeping Service Records of All Machines in the Plant

IN EVERY industrial plant of considerable size where there are many machines of various kinds, the task of keeping a service record of each machine's history, present location, and so on, is a difficult one. As a matter of fact, many plants do not keep such records, or if they do keep them, these fall far short of giving the information required. The following gives the details of a system used in a large textile plant where 15,000 machines including motors are in active use; yet the complete history of specifications, date of purchase, cost price, present and past locations are all available at a moment's notice. The value of such a system of records in case an inventory is desired of the plant equipment is not hard to realize.

Every machine and motor in the plant, whether old or new, is given a number. A brass plate about ⅞ in. wide and of the necessary length, stamped with black enamel figures, is fastened to some prominent part of the machine with escutcheon pins. The No. 44 special hardened drive pin, ¼ in. long, made by the Parker Supply Co. of Springfield, Mass., is excellent for this purpose. This pin has a steep thread cut on its surface and as it is driven into the previously drilled hole, the threaded portion cuts a corresponding groove in the metal, so that the pin will not become loose. If plain escutcheon pins are used they are very likely to come out, allowing the number plates to fall off and the identity of the machine to be lost. If the machine or motor has a manufacturer's nameplate, the plant number plate should be placed adjacent to it.

A 3-in. by 5-in. white ruled card is used for entering the number of the machine, the name of the equipment, the name of the firm from which the machine was purchased, the manufacturer's name, the date of purchase, cost price, location of machine, and so on. If the machine has a shop or manufacturer's number, that also is entered on the card, since it is an important feature in ordering repair parts. In the accompanying illustration *A* shows a typical card used for a centrifugal, turbine-driven, boiler feed pump.

MOTOR RECORD

Volts | Model | Serial # | Mill No.
Make | Kind | Full Load Speed | H. P.
Type | Form | Phase | Cycle | Amps
Temp. Rise | Date Purchased | Price

Date	Mill	Floor	Why Moved	Work	Dept. Charged	Dept. Credited	Price

Date	Record of Stoppage Hrs.	Record of Stoppage Cause	Repairs Made	By	Labor Cost	Matl. Cost

B

No. 9090
Turbine-driven, centrifugal, boiler, feed pump
Terry steam turbine 120 hp. type-C
Shop No. 319, single-stage, 1,800 r.p.m.

Worthington 5-in. three-stage pump No. 4750
Bronze impellers, capacity 600 gal. per min.
1,800 r.p.m.
Oct. 1920 $3,000
Location - First Floor of Power House
No. 40 Mill

A

Typical cards used for keeping, A, machine records, and B, motor records complete and up to date.

If a machine is broken up and scrapped the words "Broken Up" with the date are entered on the card. A blue card of the same size as the white one is then filled out with the same data that appeared on the original white card, the white card is taken from the active file and the blue card is put in its place. The white card is then placed in a separate file marked "Machines Broken Up." If a machine is sold to an outside party the same procedure is followed except that a salmon-colored card is used, and the white card is placed in a file marked "Machines Sold." If a machine is not sold or broken up but is simply taken out of active service and placed in storage, a manila-colored card is used and the white card is placed in a "Machines in Storage" file. If the machine is moved to another part of the plant, but is still kept in active use, then the new location is entered on the white card and the card still remains in its original file.

Thus at all times the active file will show first by the white cards the equipment in use, by the blue cards equipment discarded for all time, by the salmon-colored cards equipment sold and by the manila cards equipment in storage. On the other hand, the files "Machines Broken Up" and so on will show in respective groups the disposal of all equipment. In these latter files the white cards are also arranged alphabetically.

One complete set of these files with cards is kept in the office of the Mechanical Superintendent, one in the General Superintendent's office, and one in the Accounting Department where the inventories are made up. If a machine is moved, broken up, sold, or placed in storage, a special notification card to that effect is made out in the department where the machine is located, giving the details of the change; this card is sent to the Mechanical Superintendent's office. The necessary changes in the file are made there by the file clerk, and he advises the clerks in the other departments where there are similar files so that they also can make the changes. The files, therefore, show at all times the complete history of all equipment from the time the system was begun. This information will be found invaluable in many ways, but particularly when taking inventory.

In *B* of the illustration is shown a card used in the same plant for keeping a complete record of the electric motors. In a mill where there are several thousand motors, if some system is not used it is impossible to keep track of the repairs and troubles that arise. Such a motor record as is contained on this card will be of great value in showing up weak points in the manufacture, design, or maintenance of the equipment. This card measures 8½ in. by 11 in. At the top of the card is entered the same data as is on the corresponding 3-in. by 5-in. card previously described. In addition, the card shows the various locations where the motor has been, the departments to which it is charged or credited, and so on. On the lower half of the card is kept a record of the failures and repairs, by whom made and at what cost. Here again we have the complete life history of each motor at a glance. One file of these cards is located in the office of the Electrical Engineer and another in the office of the Mechanical Superintendent.

In the case of the 3-in. by 5-in. cards first mentioned, often the head of a department will wish to have a set of cards that list the machinery in his department. These two systems are very flexible, and can be altered in detail to meet any special conditions that may arise. Once installed they are easily kept up to date and will be found to be in constant use for reference.

Lawrence, Mass. A. J. CALHOUN.

Mechanical maintenance of

Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through the auxiliary transmitting equipment to all driven machines.

Method of Mounting Lineshaft Coupled Directly to Motor

ORDINARILY a motor is connected to a lineshaft either by belt or by silent or roller chain. Generally this is because the lineshaft speed, if the shaft were direct-connected to the motor, would be far above ordinary operating practice. In some lines of work, however, it is desirable to have a high operating speed for the lineshaft because that will result in a lower reduction, or increment, in the ratio of the speed between the lineshaft and the machines it drives.

At the plant of the Star Woolen Co., Cohoes, N. Y., the high speed at which the cylinders in a new rag-picking machine are operated permitted connecting a lineshaft directly to the motor through a flexible coupling.

Because the old machines in this plant were replaced with larger types of machines, it was necessary not only to strengthen the floor to support the machines, but also the ceiling, for supporting the lineshafts and motors. Each of the two rag picker groups installed consists of four main cylinders. These are driven by four 20-hp., 1,165-r.p.m. Western Electric motors. Each motor drives two cylinders and operates under a heavy load practically continuously, day and night, for about 144 hr. per week. Each of the lineshafts is 2$\frac{3}{16}$ in. in diameter and is supported on Fafnir double ball-bearing boxes and hangers, which are spaced on about 6-ft. centers. The motor is direct-connected to the end of the shaft through a Grundy flexible coupling (Chas. Bond Co., Philadelphia, Pa.). This gives practically a four-bearing suspension, taking the motor into consideration, with a flexible coupling between each of the two pairs of bearings. However, extreme care was exercised to see that the motor and the lineshaft were in perfect alignment.

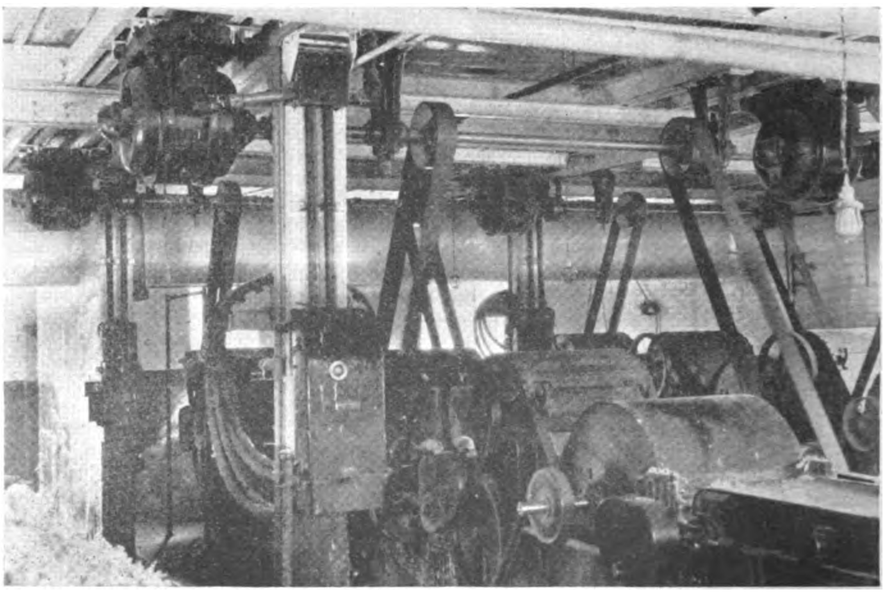
The picker cylinders weigh 750 lb., and are 36 in. in diameter and 14 in. wide. The driving motors bring them from rest to the operating speed, 1,000 r.p.m., in 20 sec. The compensators are of the G.E., totally-enclosed, CR 1034 type with push-button stop. All of the motors are of the induction, squirrel-cage type and operate on a three-phase, 40-cycle, 550-volt supply.

Two 4-in. leather belts from each lineshaft drive the two cylinders on a machine. The pulleys on the lineshaft are of cast iron, with solid rim and hub, and are 12 in. in diameter, with a 4-in. face. These are belted to 14-in. by 4-in. pulleys on the cylinders which give the speed reduction to 1,000 r.p.m. This installation has been in satisfactory operation for several months.

It was necessary to erect special steel work on the ceiling to support the motors and lineshafts. This consists of 8-in., 18-lb. I-beams with 6-in., 8-lb. channels as stringers. The channels are placed in pairs, back to back, 2 in. apart with pipe separators in between. These stringers serve as footings for supporting the lineshaft hangers and the motors.

It was also necessary to take up the flooring and strengthen it to support the machines. This was done by inserting 10-in. by 10-in. beams for the machines to rest on in place of the 3-in. by 10-in. stringers previously built in the floor. They were, of course, braced from beneath. These large beams and the stringers were of the same height and so did not interfere with laying the flooring.

THEO. P. BARNUM.
Vice-President and Secretary,
Barnum Bros. Co.,
Troy, N. Y.



These motors are direct-connected through flexible couplings to the ball-bearing lineshaft.

This illustration shows the corner of the picker room at the Star Woolen Co. The construction for supporting the motors is shown overhead at the left. Similar construction is used to support the lineshaft hangers with Fafnir double ball-bearing hanger boxes. Grundy flexible couplings were used between the motor and the lineshaft. The rag picking machine is operated at 1,000 r.p.m., while the motor drives the lineshaft at 1,165 r.p.m. This necessitates only a slight reduction in speed and permits the use of pulleys of large diameter.

Useful Chart for Determining Power Transmitted by Friction Wheels

HORSEPOWER transmitted by friction disks or wheels of different composition when used against cast-iron surfaces may be quickly determined by means of the accompanying chart. Only two simple operations are required in using this chart. How the horsepower transmitted is determined is easily explained by an example. For instance, if the width of the friction face of a wheel is 3 in., the mean diameter 20 in., and if it turns at 1,000 r.p.m., what horsepower will be transmitted by a leather fiber wheel bearing on a cast-iron wheel?

The two dotted lines drawn across the chart show how this example is solved. First, extend a straight line through the 3 (the width of the face), in column *A*, and the 20 (mean diameter of the wheel), in column *B*, and locate the point of intersection with column *C*. From that point of intersection, extend another straight line over to 1,000 (r.p.m.), in column *E;* the intersection of this line with column *D* gives the answer as 42.8 hp.

Between columns *C* and *D* are shown other combinations such as tarred fiber on cast iron, straw fiber on cast iron, and so on. When such combinations are used, find the point of intersection with column *D* in the same manner as before and then measure upward from the intersection the distance indicated by the corresponding arrows for the particular computation; the top point

thus located in column D gives the horsepower that will be transmitted, using the combination mentioned. In other words, the length of the arrow indicates the amount to be subtracted in each case because the other friction surfaces have lower transmitting capacity than leather fiber on cast iron. Thus, for example, tarred fiber on cast iron will transmit 33 hp., straw fiber on cast iron, 18 hp., wood on cast iron, 10.8 hp., leather on cast iron, 9.6 hp., and a cork composition on cast iron, 4.8 hp. These figures are readily checked on the chart by measuring upward the distances indicated.

The term "mean diameter" is used in column B, as in the case of bevel or miter wheels, the mid-diameter should be used rather than either extreme.

This chart is based on the following rule: To find the horsepower that may be transmitted by spur, miter or bevel friction drives, multiply the effective width of the face in inches by the mean diameter of the wheel in inches, then by the number of revolutions per minute made by the wheel and then by 0.00071. The result is the horsepower transmitted by a leather fiber wheel bearing on a cast-iron wheel. Where other compositions are employed in place of leather fiber, use the following constants instead of 0.00071:

Tarred fiber on cast iron...	0.00055
Straw fiber on cast iron.....	0.00030
Wood on cast iron.........	0.00018
Leather on cast iron........	0.00016
Cork product on cast iron...	0.00008

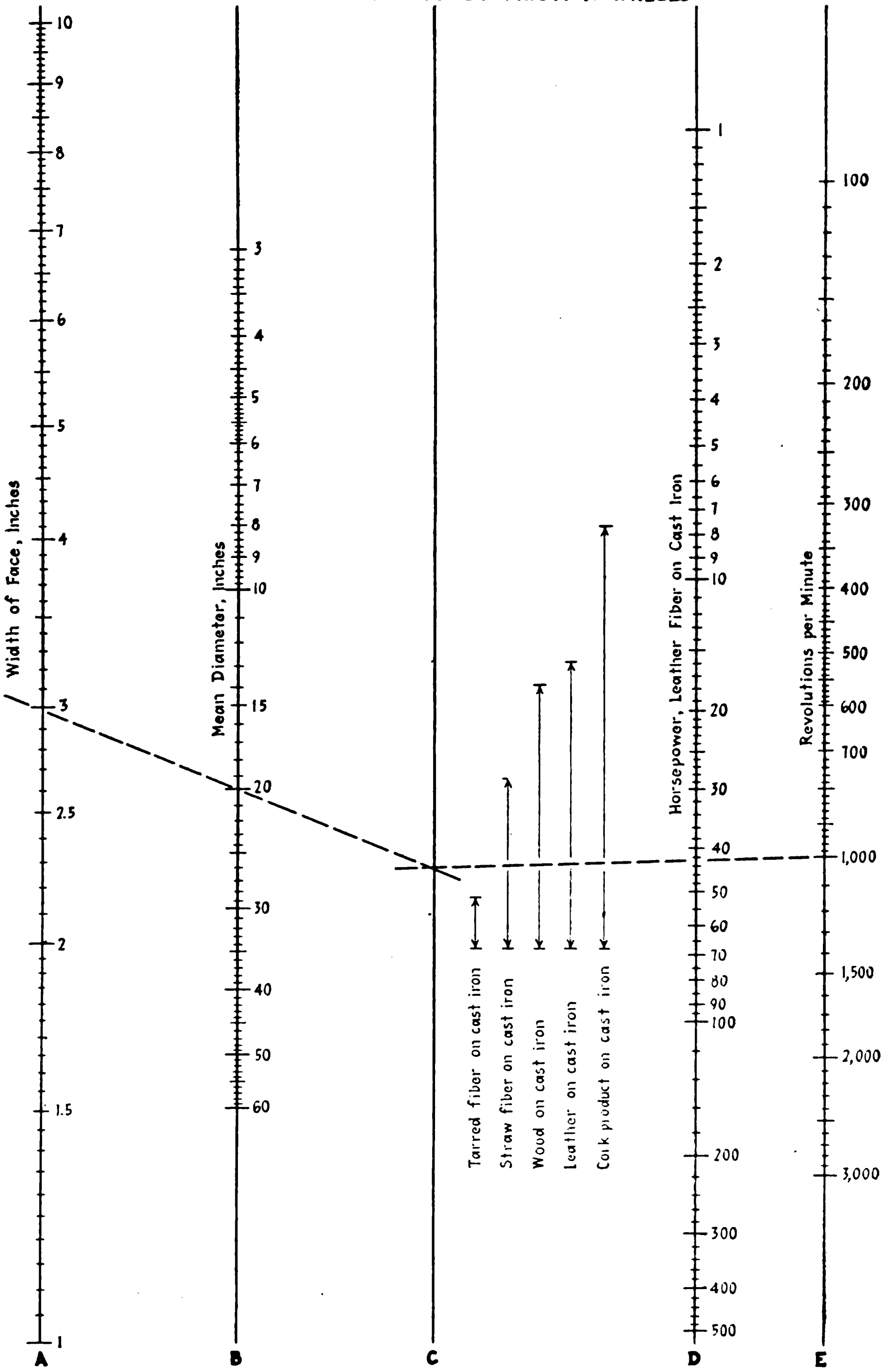
This chart may also be used in the reverse order; that is, where the horsepower, mean diameter, and revolutions are known, and it is desired to determine the proper width of face, begin at the right and the width will be found in column A. Correspondingly, when any three factors are known, the fourth may quickly be found.

W. F. Schaphorst.
Mechanical Engineer,
Newark, N. J.

With this chart the horsepower transmitted by friction disks of various composition, bearing on cast iron, may be easily determined.

In the example shown, a leather fiber friction faced wheel 3 in. wide (A) and 20 in. in diameter (B) operating at 1,000 r.p.m. will deliver (D) 42.8 hp. To get the horsepower transmitted by wheels of other composition, bearing on cast iron, proceed as with leather fiber but measure up (subtract) from the intersection on (D) the length of the arrow indicated opposite each composition.

HORSEPOWER TRANSMITTED BY FRICTION WHEELS



Individual and Small Group Machine Drives Prove Economical

COMPLETE electrification proved to be cheaper than the cost of a new boiler for Andrew Cook & Sons' sawmill in Newcastle, New South Wales, Australia. This mill was steam-engine driven and one of the principal arguments advanced against electrification was the fact that fuel cost practically nothing. Sawdust and shavings were burned and what little coal was used was mixed with these.

When a boiler at this plant was condemned recently a test was made by the Australian General Electric Co. to obtain definite figures on the comparative cost of steam engine and motor drives. The first motor installed showed that 17 hp. was being absorbed in the lineshaft. In order to improve this condition, a general rearrangement of machines was made, that involved subdividing the grouping of machines and the installation of individual and small-group drives.

The present motorization of the plant includes (*a*) a 50-hp. motor driving a 36- to 42-in. circular saw and four side planer; (*b*) a 25-hp. motor driving a bandsaw; (*c*) a 20-hp. motor driving the joiner shop of eight machines; (*d*) a 7½-hp. motor driving a docking saw, wood lathe and saw sharpener, and (*e*) a ½-hp. motor driving an emery wheel and a saw tensioning machine. General Electric motors are used.

One of the interesting points in the installation is the use of individual watt-hour meters and ammeters on each motor in order that the cost of operating each machine or group may be ascertained.

The cost of operating the mill with steam as one large group drive was approximately $400 per month; now the cost of operating it with the machines driven individually or in small groups, costs approximately $180 per month. In addition, the output of the mill has been increased 25 per cent as a result of the rearrangement.

Since this change has been made in the method of driving the plant, the management of a second sawmill has decided to change over to a similar subdivision of the drive to the equipment, with similar control and individual metering.

In the Repair Shop

This section is devoted to repair work on electrical and mechanical equipment. Special attention is given to shop or bench tools and short cuts or improved methods of handling work of this character. Contributions are always welcome.

Method of Demagnetizing a Watch in a D.C. Magnetic Field

RECENTLY I had occasion to install a piece of machinery coupled to a motor by means of a magnetic clutch. During the operation my watch became magnetized and because it was needed badly, recalled to mind an old stunt.

The watch was hung on a heavy piece of twine about 3 ft. in length, which was then twisted with as many turns as it would stand without tangling. With the clutch in operation, the watch was suspended in mid-air and allowed to rotate as the twine unwound, dropping it slowly past the clutch. The watch was demagnetized and gave no further trouble. Any d.c. magnetic field could be used to obtain the same effect.

The same method can also be used in the case of tools and other small objects which are bothersome when they become magnetized.

Chief Engineer, PHILIP N. EMIGH.
The Mountain Water Supply Co.
Indian Creek, Pa.

Changing Brush Position and Type of Winding on D. C. Motors

IN REPAIRING an old direct-current motor, it was found necessary to eliminate two features of design that had given considerable trouble. The armature of this machine had a number of burned-out coils, which had been cut open and jumpers put on the commutator bars. This patching process had been carried on until the armature winding became overloaded and burned out completely.

The electrician at the plant in which the motor operated stated that he had experienced considerable trouble with the brushes sticking in the brush box of the lower brush-holder and asked us to change the brush position if possible when rewinding the armature.

We found that the brush-holders were located on the vertical and horizontal lines as shown in diagram *A* of the illustration, and that oil had leaked past the bearing and collected on the lower brush-holder. This oil had become gummy and caused the brush to stick, with sparking as a result.

The armature was checked and the data found to be as follows: 87 slots, 87 bars, lap winding, coil pitch 1-and-22, with the top leads connected straight out and all the throw in the bottom leads as shown in diagram *A*. There were 87 diamond-shaped, pulled coils, each wound with six turns of No. 12 d.c.c. round wire. These coils were built up two wires wide by three deep, and were what is termed cross-overs; that is, the coils were wound on a shuttle with one wire in hand and the cross-over placed at the front diamond point.

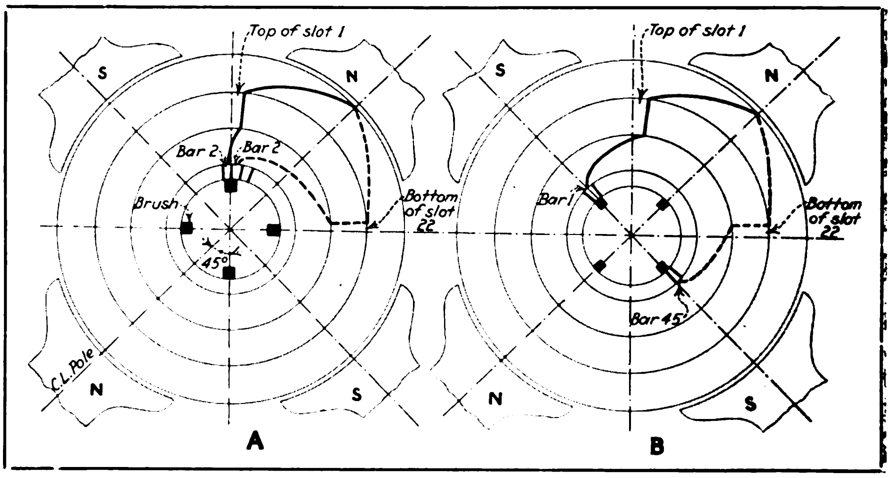
It was thought that the cross-overs were the cause of so many coils becoming short-circuited. On the front end of the winding there was a band that appeared to have been put on with considerable pounding to shape the ends; this pounding had weakened the insulation on the wire at the cross-over.

It was decided to move the brush position 45 deg. and change to a wave winding. The reason for choosing the wave winding was to eliminate the cross-over in the coils. A two-circuit winding has twice as many coils in series per path as the corresponding lap winding; therefore, we could wind the coils with three turns of two No. 12 wires in parallel, reducing the number of turns one-half, thus making a cheaper and better coil, and still retain the same operating conditions. The commutator necks had to be milled out to take the No. 12 wires four deep.

The wave winding data and the new brush position are shown in diagram *B*. The lead pitch is 1-and-45, resulting in a progressive winding, with the top and bottom lead throws evenly spaced on either side of the center line.

By making the changes described above, we were able to eliminate two unsatisfactory features of the motor and at the same time produce a good job at a low cost. A. C. ROE.
Wilkinsburg, Pa.

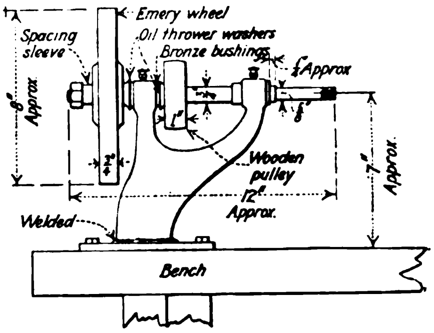
This shows, A, original brush position and lap winding and, B, brush position and new wave winding.



Inexpensive Grinder Made From Automobile Parts

AN EXAMPLE of what may be done with discarded automobile parts when necessity demands the use of material at hand, is shown by the grinder described below.

The frame of this grinder is made from a discarded automobile or truck front axle of the type which uses bushings in the steering knuckle bolt holes. Saw this off approximately 7 in. from



The frame of this grinder was made from one end of the front axle of an automobile.

The shaft was made from a piece of steering rod, and the pulley was turned out of hardwood.

one end; be careful to saw along a line parallel with the holes in the opposite end. Obtain an automobile spring plate, which has four holes in it, so that it can be bolted to a bench, and weld the piece of axle securely to it.

The shaft can be made from a piece of ⅞-in. solid steering rod, which should be cut to the proper length and accurately centered. It should be turned down to a diameter of ⅝ in. at each end,

leaving a shoulder approximately 1/4-in. wide outside the bearing. If necessary, true the part between the two shoulders, but do not turn it down any more than necessary. Both ends of the shaft should be threaded in the lathe and fitted with nuts which should, while screwed on the shaft, be faced on the side to clamp the wheel. The oil thrower washers should be made with a force fit, so that they will turn with the shaft, and mounted in the 1/4-in. space left between the shoulders and outer end of the bearings. They should be beveled as shown to keep oil off the grinding wheel and pulley and can be made from discarded bronze bushings having a flange. The emery wheel washers may be made of cast iron; the inside washer should be a tight force or shrink fit and afterwards turned true.

A wooden pulley can be turned down from walnut or other hardwood and held on the shaft by a machine screw threaded into the wood, which clamps on a flat place filed on the shaft. This pulley should be made after determining the proper speed required by the emery wheel selected.

Oil holes should contain a small piece of felt wick which touches the shaft. This admits oil gradually and also strains it. Bearings should be fitted accurately, finished with an expanding reamer and should be in proper alignment. If the holes in the axle are out of line, the bearings can be made self-aligning and secured by a setscrew.

A 1/8- or 1/4-hp. motor, set on a bench at the rear of the grinder and belted to it with a 1-in. or 1½-in. belt will operate it satisfactorily. The grinder described has been in use for over one year and no wear can be detected in the bearings. Owing to the fact that it was made with a small amount of labor and from waste material, this grinder has been worth many times what it cost.

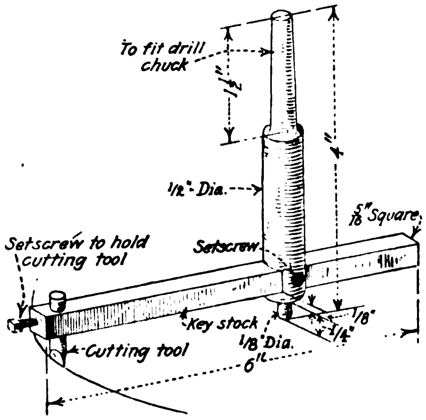
Durant, Okla. J. P. KINCAID.

Simple Time-Saving Device for Cutting Fiber Washers

IN ORDER to save time, a simple tool for cutting out fiber washers was recently made which has proved indispensable in our work. The old method used was to cut them out in a lathe, and was a very slow process in comparison with the results obtained from the device shown in the accompanying sketch.

A piece of cold-rolled steel 1/2 in. in diameter and 4 in. long was turned down on one end for a distance of 1½ in. to fit a drill chuck; the other end was turned down to a diameter of 1/8 in. for a distance of 1/4 in., to act as a guide. A 5/16-in. hole was drilled 1/8 in. back from the shoulder on the guide end, and filed square to take an arm made from a 5/16-in. square piece of key stock. This arm is 6 in. long and is given a sliding fit so that it can be adjusted for length. It is held in place by a 5/16-in. setscrew in the steel shaft. Another hole was drilled in the outer end of the key stock to insert a piece of tool steel or other material suitable for cutting fiber. The cutting tool is likewise held in place by a setscrew.

The tool is used as follows: Use a pair of dividers to scribe out the size of washers desired. Then drill a 1/8-in. hole in the center of each washer, which is already centered by the pivot of the dividers. Set the tool to cut the outside diameter first; then, after as many



Here is a tool that will simplify the job of cutting fiber washers.

washers as are required have been cut, set the tool for the inside diameter.

Any size of washer from 3/4-in. up to 5-in. bore can easily be made in this way. There is always a demand for fiber washers in repair shops; so a tool of this sort which requires only 1½ hr. to make, will soon save its cost many times over.

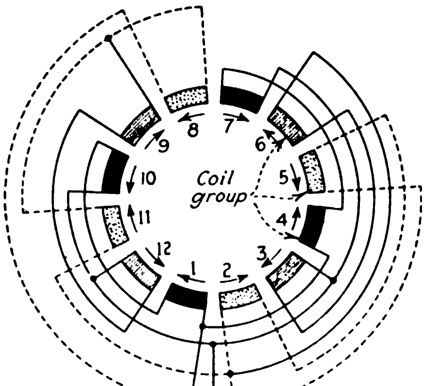
NICHOLAS J. WEISS.
West New York, N. J.

Calculating New Winding for Small Induction Motor

IN CALCULATING a new winding for a small induction motor from which the old winding had been removed, the following procedure was followed:

The rating of this motor as shown on the nameplate was three phase, 60 cycles, 220 volts, 8.35 amp., 1,800 r.p.m., and 3 hp. The number of poles equals (120 × frequency) ÷ r.p.m. = (120 × 60) ÷ 1,800 = 4. For a full-pitch winding the coil span would be equal to 36 ÷ 4 = 9, since the stator had 36 slots and this was a four-pole machine.

Using a delta connection, the phase voltage is equal to the line voltage and the phase current is equal to the line



This shows the new three-phase, four-pole, two-parallel, delta winding, consisting of 36 coils, 36 turns per coil, and 12 groups.

current divided by 1.73. Two constants must be used; the number of volts per turn, V_t = 1, and the circ.mil per amp. = 550.

As we had a large supply of No. 19 d.c.c. and enameled wire, which has an area of 1,288 circ.mils, it was decided to use it, if possible. Phase current for a delta connection is 8.35 ÷ 1.73 = 4.82 amp., and using 550 circ.mils per amp., the total area required would equal 550 × 4.82 = 2,650 circ.mil. Two No. 19 wires in parallel have an area of 2 × 1,288 = 2,576 circ.mils which is close enough for all practical purposes. By using the two wires in parallel, a two-parallel, delta connection may be used.

Then $V_t = 1 = 220 \div (2 \times 3 \times N)$, or $N = 220 \div 6 = 36.6$ turns per coil.

The accompanying diagram shows the four-pole, two-parallel, delta-connected winding, in which there are 12 pole-phase groups. Two groups are in series and the line voltage is impressed across them. There are 12 groups and 36 coils which allows three coils to be connected in series per group.

If it were considered desirable to chord the winding, the number of turns would have to be increased slightly and the span decreased. If the coil span is eight slots, the chord factor equals the sin of ½ (180 × 8/9) = sin of 80 deg. = 0.9848. The number of turns in a coil for a full-pitch winding must be divided by 0.9848 to obtain the number of turns to use for a span of eight slots; that is, $N = 36.6 \div 0.9848 = 37.2$, or 37 turns per coil.

Values used for volts per turn and circ.mils per amp. will depend upon the speed of the motor and the kind of frame, that is, whether open or closed.

CHAS. F. CAMERON.
Rock Springs, Wyo.

How to Prevent Bending Armature Shaft When Forcing Commutator On

THE lesson I learned from a mistake which nearly cost me my first job in a repair shop, may be of interest to other readers of INDUSTRIAL ENGINEER.

One day I was using a hydraulic press to force a commutator on a small core with a long shaft, applying pressure directly to the end of the shaft. The commutator fitted so tightly that I had to apply a good deal of pressure, with the result that I bent the shaft badly. Of course, that meant considerable extra work and I did not blame the foreman for getting angry at me. Since then I have always placed over the shaft a piece of pipe that is longer than the shaft itself, and have had no more trouble.

Repairmen do not always realize that the shaft of a small motor is rather easily bent and it is not an easy matter to get it straight again. If armature cores of any size are handled roughly or allowed to drop on the floor there is danger of not only bending the shaft, but also of burring or otherwise injuring the laminations. Such injuries may be the unsuspected cause of heating of the armature, due to eddy currents.

Newark, N. J. SAMUEL CARBAT.

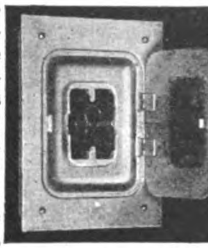
New Equipment

for plant operation and maintenance

Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these new devices which are designed to improve plant operation or reduce operating and maintenance costs.

Safety Fuse Carrier

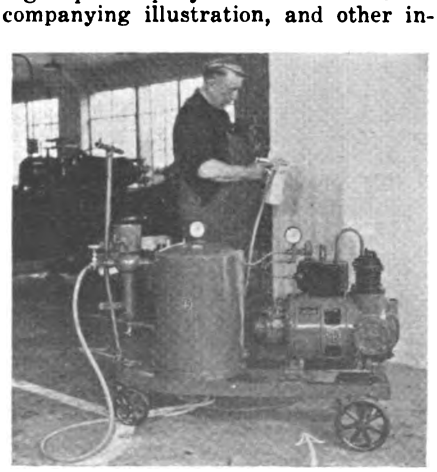
NEW features in safe switching and fusing are announced by the Mutual Electric & Machine Co., 7610 Jos. Campeau Ave., Detroit, Mich., in a new Bull Dog SAFtoFUSE (pronounced safe-to-fuse) fuse carrier, shown in the accompanying illustration. This unit is made in 30-amp. and 60-amp., 250-volt sizes. These fuse carriers have switch contacts which may be withdrawn from the receptacle base. When the carrier is in the "on" position, the fuse acts to fill the gap between the blade contacts, and the molded composition unit must be fully withdrawn before the fuses are accessible. The molded unit may also be inserted in the receptacle upside-down which shows the fuses exposed, but in this position they are dead. Suitable means are provided for testing fuses.



The types now being put on the market are enclosed in steel cabinets with luminized fronts. They are particularly adapted for industrial plants where safety in fusing, appearance and compactness are required. Bulletins 102, 103 and 104, which describe this equipment and its application, are now available.

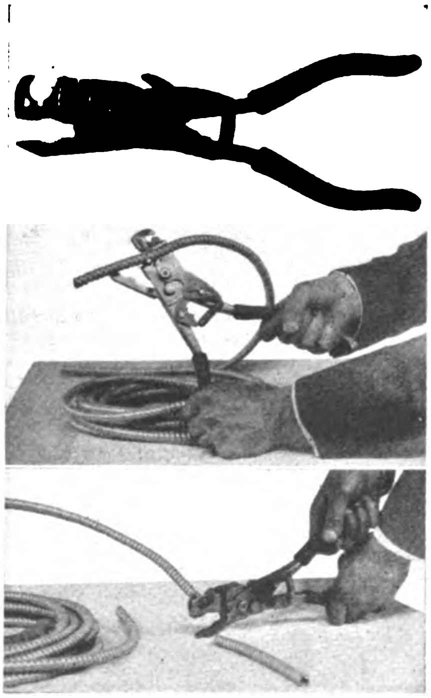
Portable Air Compressor

INDUSTRIAL plants having use for compressed air and without piped air distribution will be interested in the new H. B portable compressed air unit which is announced by The Hobart Brothers Co., Box MS-5, Troy, Ohio. This unit may be used to supply air for cleaning machinery, motors, operating a paint spray as shown in the accompanying illustration, and other industrial purposes within its capacity. This unit is an H B silent, twin, heavy-duty, motor-driven compressor with a capacity of 8 cu.ft. per min. at 85 lb. maximum pressure. This equipment is mounted on a three-wheeled, rubber-tired truck with 25 ft. cable and a 15-gal. air tank. The paint spray gun, 25 ft. of hose and paint receptacles are included. The compressor can be furnished either with automatic start and stop pressure switch, or arranged for continuous operation at a given pressure.



Tool for Armored Cable

THE accompanying illustrations show the triangle armored cable tool, manufactured by the Triangle Conduit Co., Inc., Dry Harbor and Cooper Ave., Brooklyn, N. Y., and the method of operation. The manufacturer states that this tool has eliminated one of the difficulties experienced heretofore in installing armored cable in that it facilitates the quick and clean stripping of the steel from the wire without injuring the conductors or their insulation.



The tool, shown at the top of the accompanying illustration, consists of a pair of steel pliers, 11½ in. in length, weighing only 2 lb., and operates on an entirely new principle. It is stated that it will strip any single-strip armored cable in sizes 14/2, 14/3 or 12/2 without any adjustment. The wireman slips the tool on the cable as shown in the center illustration, opens and closes the handles and the operation is complete except for sliding off the steel armor.

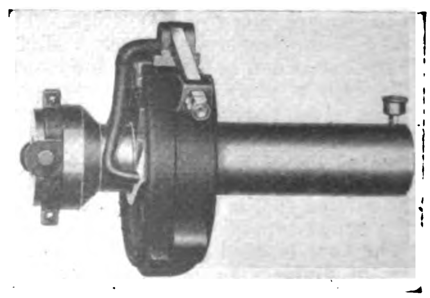
The tool also has an auxiliary pair of wide-mouth pliers with extra-heavy leverage, which, it is said, performs all the functions of ordinary gas pliers, as well as a cutting device which cuts wire, cable or non-metallic conduit up to ¾ in. outside diameter, as shown in the lower illustration. Both blades are good for 10,000 to 15,000 cuts, it is stated.

Non-Refillable Plug Fuse

SEVERAL distinctive features are incorporated in a new, non-renewable plug fuse recently placed on the market by the Trico Fuse Manufacturing Co., Milwaukee, Wis., under the trade name of Cleartop. The fuse consists of a separate porcelain base and body. The base has a long baffle chamber which extends to the inside top of the body and holds the mica window in place. The body and base are held together by a heavy brass screw shell. The body is finished in a dull black, giving the appearance of molded insulation. Some of the distinctive features claimed for this fuse are, provision of a large, rugged knurl around the top edge to afford a good grip when tightening; the fusible strip has a restricted blowing portion; each strip has the rated current stamped plainly on the top and is visible through the mica window. A vent space is provided around the base so that the gases escape along the exterior of the base within the body and are gradually released along the base. The body and base are molded from a high grade of porcelain. The base supports the mica disk as well as the fuse strip and acts as a fireproof barrier to prevent interior flashovers. A large center contact is riveted to the base.

Compression Clutch

HERETOFORE the compression clutch shown in the accompanying illustration was made only for the manufacturers of machines. The Conway Clutch Co., 1935 West Sixth St., Cincinnati, Ohio, announces that this type of clutch will now be available for shop equipment drives. Features that have made this clutch desirable for severe conditions of service are said to be its easy engagement, quick release, idling without drag, and the ability to deliver power to the belt. The sleeve member is equipped with

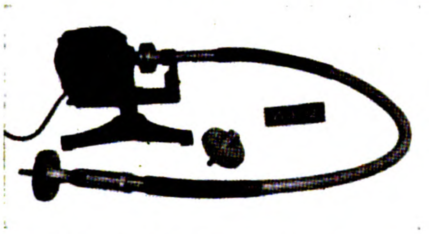


bronze bushings and has a full-length bearing for its over-all length.

These clutches range in power capacity from 1 to 50 hp. at 100 r.p.m.; the smaller sizes, it is stated, can be operated at speeds exceeding 600 r.p.m. Dimensions vary from 4 in. in length by 2½ in. in diameter for the sleeve, and 9½ in. over-all, to 12 in. in length by 5½ in. in diameter for the sleeve and 22½ in. over-all. Maximum bore for 1 hp. is 1 3/16 in. and for 50 hp. it is 3½ in. The manufacturer states that all parts are easily accessible and the lever arm so constructed that any end thrust which the cone delivers is taken care of when the clutch engages. It is also stated that the friction band is a full-floating member which, in addition to delivering power, serves as the principal factor in release.

Flexible Power Unit

THE new flexible power unit shown in the accompanying illustration has been placed on the market by Sirianni & Trumbettas Mfg. Co., 110 Farview St., Carbondale, Pa. This unit comprises a motor and a flexible power shaft made



for driving interchangeable brushes, drills, grinding or buffing wheels, and other tools.

The core or driving element of the flexible shaft is constructed of tightly-wound steel wires. The manufacturer states that the ½-in. size core will drive a ½-in. drill in metal. The oil-tight protective covering of the core is of zinc-plated steel. Inside this casing is a coil of tempered flat steel wire which forms the bearing surface for the core or driver to ride upon. It is stated that this flexible shaft is capable of operating at 2,200 r.p.m.

The driving motor can be placed wherever desired. The unit is mounted on a swivel base which permits it to swing around in a complete circle. Ball bearings for the motor will be furnished on request. General uses for this unit are drilling, grinding, polishing, buffing, sanding, cleaning, and commutator slotting as well as removal of paint and rust.

Pipe Bending Vise

ANNOUNCEMENT is made that Paul W. Koch & Co., 33 S. Wells St., Chicago, Ill., are now marketing the new Jiffy pipe bender vise shown in an accompanying illustration, in which ½-in. and ¾-in. conduit may be cut, threaded, and bent without removing from the vise. As a vise it will take conduit up to 2 in. in diameter, although the construction of the vise is said to be much heavier than the standard 2-in. size.

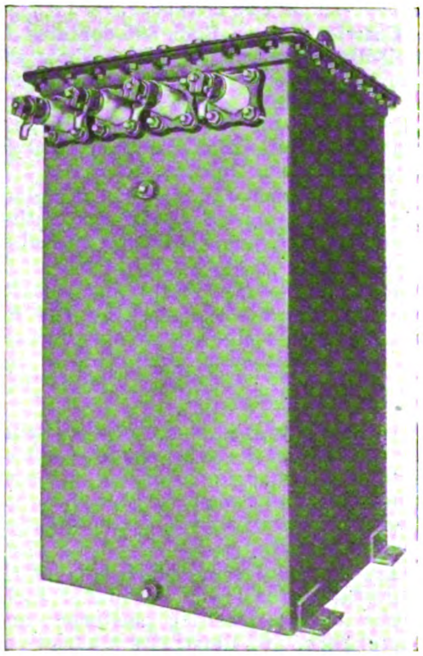
The bender is designed to make offsets, saddles, goose-necks and other difficult bends. It is adjustable for bending either downward or sidewise.

That it eliminates possible chances of injury by the hickey slipping or pipe breaking and also reduces, in some instances, the number of fittings required on the job, is also claimed.

The manufacturer also states that the bender does not flatten or kink the pipe as the forms and roller hold the pipe to shape and permit a radius as small as 2 in. without opening the seams. The operation is purely mechanical after the measurements have been taken. The vise is shipped in a box which is so arranged that it makes a permanent tool box for it.

Shovel-Type Transformer with Oil-Tight Tank

A NEW shovel-type transformer shown in an accompanying illustration has recently been designed and placed on the market by the Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa. The outstanding characteristics of this transformer are a heavy end-frame construction, a welded sheet-metal tank, and additional bracing to prevent the transformer



from sliding around inside the tank. This transformer has been designed for use in applications that require a transformer having oil-tight tank and bushings.

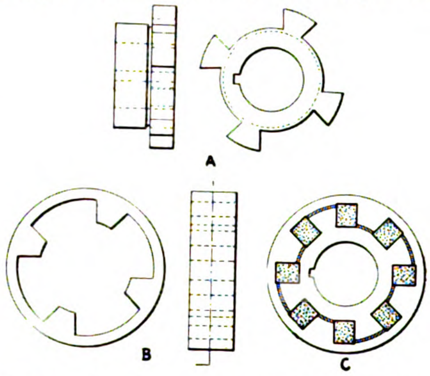
One specific application is on electrically operated shovels, which subject the transformer to vibration and shock. In such service the transformer is inclined at various angles which might cause leakage of oil and consequent overheating and injury if the ordinary type of distribution transformer were used.

Cement and flour mills where the fine dust finds its way into the ordinary transformers, and causes clogging of ventilating ducts, spoilage of oil and costly overheating of the transformer, and mine service and subway installations, are other suggested applications of this new shovel-type transformer.

These new transformers are manufactured at present for 2,300-volt, single-phase, 60-cycle, service, but it is possible to obtain them in other voltages.

New Flexible Coupling

EASE of assembly and disassembly are two of the advantages claimed for a new type of flexible coupling which has been placed on the market by The Clark Controller Company, 1146 152nd St., Cleveland, Ohio. This coupling consists of two duplicate flanges, as shown at *A* in the accompanying drawing, one outer sleeve, *B*, and eight pieces of resilient material, such as standard hydraulic packing. The flanges are keyed to the separate



shafts; the sleeve goes over the flanges and the resilient material is placed between the lugs on the flanges and sleeve respectively. The assembled coupling is shown at *C*. Steel springs and phosphor bronze retaining rings at each end of the outer sleeve hold the sleeve and packing in place. In this way the equipment is assembled without any projecting bolts.

It is stated that whenever it becomes necessary to change armatures on motor-driven applications, the retaining rings are removed, the sleeve slid back over one of the flanges, the packing removed and the armature with its half-couplings can then be lifted out. A spare armature shaft with a half-coupling of the same rating keyed on it can then be inserted quickly and the coupling re-assembled. It is also stated that the coupling is adaptable to reversing as well as non-reversing drives and also allows a large margin of angular and vertical misalignment as well as end float.

Trade Literature

you should know about

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Threadless Conduit Fittings—An 80-page booklet entitled "The Story of the Kondu-Box," contains a description and listing of the various types of Kondu threadless, malleable-iron conduit fittings, gives a number of the advantages claimed for them, and illustrates many applications.—Erie Malleable Iron Co., Kondu Division, Erie, Pa.

Air Tools—In Booklet 131, which is entitled "Speed Up with Air," are shown applications of the various Sullivan air tools and air compressors.—Sullivan Machinery Co., 120 So. Michigan Ave., Chicago, Ill.

Capacitors — Bulletin GEA-352 contains nine interesting reports on the use of Capacitors for power factor correction and indicates the savings made possible in each case.—General Electric Co., Schenectady, N. Y.

Speed Measuring Instruments—Bulletin 1105 describes the Jagabi speed indicator, and hand tachometers, tachoscopes and tachographs for the accurate indication, measurement, and recording of speeds.—James G. Biddle, 1211-13 Arch St., Philadelphia, Pa.

Switchboards—Publication 1006-2 describes the line of Condit built switchboards for every industry and illustrates a large number of applications. —Condit Electrical Mfg. Corp., Hyde Park, Boston, Mass.

Automatic D.-C. Starter—Bulletin 215 describes the Type C-1220, current-limit, automatic, d.-c. starter which is used for starting constant-speed, shunt-or compound-wound motors up to 30 hp. at 115 volts and 50 hp. at 230 or 500 volts, for any applications where it is desired that the time of acceleration correspond with the load on the motor. —Allen-Bradley Co., Milwaukee, Wis.

Pressure Blowers and Exhausters—Bulletin 1608 describes the A B C special blowers and exhausters for mines, cupolas, forges, furnaces, and other applications. These are built in standard sizes to deliver pressures up to 12 oz. per sq.in.; special blowers are designed for pressures up to 24 oz.—American Blower Co., Detroit, Mich.

Watthour Meters—Bulletin 70 is a book of instructions on the installation and operation of Sangamo Type H single- and polyphase watthour meters. Numerous connections are shown by diagrams. — Sangamo Electric Co., Springfield, Ill.

Unit Heaters—An 8-page folder discusses floor mounting versus overhead suspension of unit heaters in industrial plants, illustrates the circulation of heat from both, and discusses where each type may be used to best advantage. —York Heating & Ventilating Corp., 1502 Locust St., Philadelphia, Pa.

Air Compressors—The 16-page Form 126, describes and illustrates the construction and operation of Pennsylvania duplex, single-stage and two-stage, cross-compound air compressors.—Pennsylvania Pump & Compressor Co., Easton, Pa.

Dust Mask—A folder describes the use of the Epco dust mask for cleaning and maintenance work in dusty locations. This consists of a hood with respirator and non-shatterable vision glasses.—The Engineering Products Corp., Inc., 64 Wall St., New York City.

Mica Undercutting Machines—An 8-page booklet illustrates, describes and gives the advantages claimed for the types Nos. 2, 6 and 9 of the Hullhorst mica undercutting machine, together with a description and price list of the Hullhorst small-disc mica cutters.—The Hullhorst Micro Tool Co., Dept. 2, Toledo, Ohio.

Disconnecting Hanger—Catalog E-26 illustrates the use, shows various models, and describes several of the various methods of installing the Thompson safety lowering switch or disconnecting hanger for lamp maintenance.—The Thompson Electric Co., 1438 W. 9th St., Cleveland, Ohio.

Pyrometers—A 68-page booklet entitled "Instructions for Installation and Care of Thermo-Electric Pyrometers" discusses the thermo-electric pyrometer, its installation, and the checking of pyrometer installations. This booklet is illustrated with numerous diagrams and photographs.—The Brown Instrument Co., Wayne and Windrim Aves., Philadelphia, Pa.

Conduit Fittings—Folder 30 illustrates and describes the line of Crouse-Hinds condulets with fuse cutouts.—Crouse-Hinds Co., Syracuse, N. Y.

Crawler Crane—Book 895 contains 48 well-illustrated pages, which show the use of dragline, dipper and trench shovel, skimmer scoop, hook blocks and pile driver on the new All-Purpose crawler crane.—Link Belt Co., 910 S. Michigan Ave., Chicago, Ill.

Lamp Guard—A circular describes the Loxon lamp guard for preventing breakage and unauthorized removal.—McGill Mfg. Co., Valparaiso, Ind.

Recorder — An interesting booklet compares the records made by Tag instruments to a plant newspaper recording all operation of equipment in the plant.—C. J. Hagliabue Mfg. Co., Brooklyn, N. Y.

Isolating Material—A 12-page bulletin describes the use of Korfund, a cork insulation, for isolating machine vibrations and shows diagrams of numerous installations.—The Korfund Co., Inc., New York, N. Y.

Trucks and Tiering Machines—A 32-page catalog describes the line of Jack-lifts, stackers, steel-leg platforms, and barrel racks and illustrates a variety of applications of this equipment in different industrial works. — Lewis-Shepard Co., Watertown Station, Boston, Mass.

Vapor-Proof Electrical Fixtures—Bulletin A describes the interchangeable line of vapor-proof electrical fixtures and watertight conduit boxes and fittings for industrial, railroad and marine service.—Seidler-Miner Co., 316 E. Jefferson Ave., Detroit, Mich.

Steel Poles—A 36-page catalog describes the Truscon copper-alloy steel poles and gives considerable engineering data on their use for erecting transmission lines or in building substations. —Truscon Steel Co., Youngstown, Ohio.

Floodlight Projectors—Folder 33 and Bulletin 2083 describe the construction and illustrate a number of applications of the Imperial short-range floodlight projector. — Crouse-Hinds Co., Syracuse, N. Y.

Transformer Data—No. 7 of a series of monthly bulletins of technical information on transformers gives diagrams and an explanation of the use of the delta connection.—Moloney Electric Co., St. Louis, Mo.

Variable-Speed Transmission—A circular discusses the use of remote control with the Lewellen variable-speed transmission to obtain the proper operating speed.—Lewellen Mfg. Co., Columbus, Ind.

Tramrails—An eight-page folder describes and illustrates a number of installations of Cleveland hand and electric tramrail systems in a wide variety of industrial plants.—Cleveland Electric Tramrails, Division of The Cleveland Crane & Engineering Co., Wickliffe, Ohio.

Cable End Bells — An eight-page booklet gives a number of the salient features of the Three E indoor and outdoor cable end bells and illustrates a number of the types.—Electrical Engineers Equipment Co., Chicago, Ill.

Blow Torch—A circular describes the Unique gasoline blow torch and firepot. —Unique Mfg. Co., 113 N. Desplaines St., Chicago, Ill.

Lifting Jacks — A circular describes the Duff governor-controlled, ball-bearing, self-lowering jack, which is made in capacities of 15 to 50 tons.—The Duff Mfg. Co., Pittsburgh, Pa.

Speed Reducer—A catalog of the Lipe Products, describes the speed reducer which is built in standard gear ratios of 4:1 to 100:1 and in special combination worm and spur gear units with ratios of 48:1 to 7,000:1, and in sizes up to a maximum load of 500 hp. This catalog also lists the Lipe electric hoists, flexible couplings and an internal geared conveyor pulley.—W. T. Lipe, Inc., 208 So. Geddes St., Syracuse, N. Y.

Lightning Arrester.—Bulletin 220 describes the Keystone expulsion type lightning arresters. — Electric Service Supplies Co., 50 Church St., New York, N. Y.

Industrial Control—A 160-page catalog GEA-257, includes a reprint of the industrial control section of the General Electric catalog, gives instructive matter on the care and operation of control devices, wiring diagrams of controls, reference tables, and other useful information. — General Electric Co., Schenectady, N. Y.

INDUSTRIAL ENGINEER

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Details of the

Topics Discussed by Steel Men

at the Twenty-Second Annual Convention of the Association of Iron and Steel Electrical Engineers held last month at Chicago, Ill.

WORTH-WHILE accomplishments in the way of standardization and safety, coupled with a very successful Exposition marked the Twenty-Second Annual Convention of the Association of Iron & Steel Electrical Engineers at Chicago, June 7 to 11. On the first day of the convention the recommendations of the Safety Committee regarding the safe operation of cranes was discussed and unanimously adopted by those in attendance. The safety code and the discussion on it are given on page 299.

The second day was devoted to electric transportation, as this is a problem that will be confronting most steel plants in the very near future, if not at present. Abstracts of the papers on this subject are given on page 303. The subject of most interest to the membership on the third day was the report of the Standardization Committee relative to standardizing mill-type motors. The recommended standards for mill-type motors are given on this page.

On the fourth day the report of the Electric Heat Committee was presented, details of which are given on page 301.

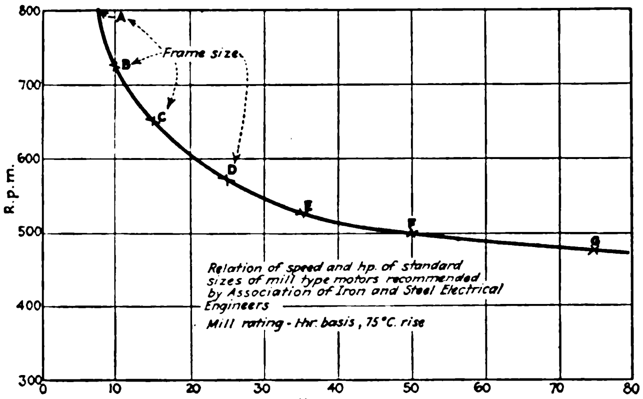
An unusually successful exposition of machinery used in the manufacture of iron and steel was held, 76 exhibitors showing products ranging from motors to air cleaners and from fire brick to electric industrial trucks, as well as control equipment, lubricating equipment, anti-friction bearings, switching equipment, electric heating devices, armature repair tools, storage batteries and lighting equipment.

In the following pages are given abstracts of the papers together with the discussions on them.

Standardization of Mill-Type Motors

By A. C. CUMMINS *Chairman, Standardization Committee, Electrical Engineer, Duquesne Works, Carnegie Steel Co.*

Due to the fact that a great deal of the work on standardization of mill-type motors was done shortly prior to the convention, Mr. Cummins was unable to present a formal paper, but spoke extemporaneously on the different points on which he and the committee had been able to reach an agreement. Mr. Cummins first outlined the steps which led to the calling of a standardization committee on this particular subject. Late last year he learned that one large manufacturer of mill-type motors contemplated bringing out a new line of these mill-type motors. Believing that this was an opportune time to effect standardization of mill-type motors, a committee was appointed and the first meeting was held at Duquesne Works, December 11th, 1925. First, letters were sent to the presidents of all the steel companies to ascertain if they favored such a step, and also to apprise them of the interest of steel mill electrical engineers in inventory reduction and consequent reduction in maintenance



Horsepower and speed of standard mill-type motors recommended by Association of Iron & Steel Electrical Engineers.

The points marked *A, B, C*, etc., refer to the frame sizes selected by the Standardization Committee. The curve shows the speed horsepower relation for the seven standard sizes selected. The data given by the curve is the mill rating on the 1-hr. basis with a temperature rise of 75 deg. C. More complete data is given in the table on page 298.

Characteristics of Recommended Standard Mill-Type Motors

Frame Size	Mill Rating			Crane Rating		Recommended Sizes of Anti-Friction Bearings			Diameter Armature Shaft at Bearing
	Hp.	Speed	Torque	Hp.	Torque	Armature Bearings	Axle Bearings		
A	7½	800	49	10	76	311	216	313	2.1654
B	10	725	72	13	109	311	218	315	2.1654
C	15	650	121	20	188	313	220	317	2.5591
D	25	575	228	33	350	316	222	319	3.1496
E	35	525	350	45	520	317	224	320	3.3465
F	50	500	525	65	795	319	226	321	3.7402
G	75	475	830	100	1,280	322	230	322	4.3307

costs. The replies from the presidents of the various steel companies were very gratifying and were almost unanimous in approval of the steps contemplated by the Standardization Committee. However, the presidents of several steel corporations pointed out that the Standardization Committee should limit standardization to external features of the motor and the determination of standard horsepowers and speeds. They felt it was not the duty of the Association to go inside of the motor. In this connection, Mr. Cummins pointed out that it was not the attitude of the Association to ask the manufacturers of mill-type motors to immediately bring out a new line of motors to meet the recommended standards but rather to come to the standard of the Association as soon as they were able or desired to bring out a new line of motors.

Letters were then sent to the manufacturers of mill-type motors and also to some other manufacturers, asking that they send representatives to a meeting in which some attempt would be made at standardization. The first meeting was held in March, at which representatives were present from the Electro-Dynamic Company, the Allis-Chalmers Mfg. Co., Reliance Electric & Engineering Co., Crocker-Wheeler Electric Mfg. Co., Westinghouse Electric & Mfg. Co., and General Electric Co. Only the last three of these companies are manufacturers of mill-type motors, but the other three were sufficiently interested in standardization of motors (due to the possibility of their bringing out a mill-type motor in the future) to desire to have a part in the standardization program. In the meantime, letters had been sent to the membership of the Association, asking leading questions relative to the points on which standardization was desired, and also just what steps were favored and what were disapproved. Letters were sent to approximately 350 active members and some 160 replies were received.

The method of approach in the matter of standardization was to plot the various characteristics of the different mill-type motors now on the market and then strike an average between them, based on the experience and the desire of the Standardization Committee and the representatives of the different manufacturers. For instance, in determining the relation between the frame sizes and horsepower ratings, a graph was drawn with horsepower as abscissæ and frame size as ordinates. Curves were plotted for the General Electric type MD motors, the Crocker-Wheeler Type CW motors, and the Westinghouse type MC motors. A fourth curve was then drawn which averaged the conditions of the other three curves and at the same time represented what the committee and the manufacutrers thought would be desirable. It so happened that the curve for the standard motor fell nearest to the Crocker-Wheeler motor for this particular characteristic. Additional curves were then drawn for other motor characteristics; for instance, a curve was drawn showing the relation between speed and horsepower for the different frame sizes. In this case the recommended speed for the standard motor was higher than that of the type MC motor, but lower than for both the type MD and type CW motors. This was also true of the torque curve. The accompanying diagram shows the relation of speed and horsepower for the standard sizes of mill-type motors as recommended by the Standardization Committee. In this curve the motor is rated on the mill rating of a 1-hr. basis with a temperature rise of 75 deg. C. Other curves from which standard curves were made, showed the relation between frame size and speed, the relation between frame size and per cent increase in horsepower above previous size, and the relation between actual increase in horsepower between sizes and the frame size.

From these curves it was found that the present eleven frame sizes in use could be reduced to eight. Further investigations brought out the fact that one manufacturer sold only three per cent of his entire output of mill-type motors in the largest or 100-hp. size and therefore this size was also eliminated from the standardization program. In the accompanying table are given the characteristics for the seven standard frame sizes for both the mill rating and crane rating, listing horsepower and speed as well as torque. The standard sizes of anti-friction bearings for armature bearings and axle bearings, as well as the diameter of the armature shaft at the bearings, are also shown.

The diameter of the jackshaft or axle bearings as recommended by the Committee range in size from 3½ in. to 5⅞ in., depending on the rating of the motor. These sizes have been selected so that these shafts will have the same factor of safety as the other shafts ordinarily used on the driven equipment.

In attempting to standardize the different classes of motors, it was found that there were two fundamentals which determine the design. These are the height of the armature shaft above the bedplate, and the length between the armature bearing centers. Once an agreement has been reached on these two dimensions, it is not difficult to reconcile the remaining differences. In most cases the recommended standard heights for the different sizes of standard mill-type motors are slightly less than the height of the existing mill-type motors. The over-all length is approximately the same as on existing types. This results in getting a little more motor in the same space in the case of the new standard motor.

Standards were agreed upon for the face, diametral pitch, and general dimensions of the motor pinions for the different sizes of motors.

In determining the armature shaft sizes for the recommended standard motors, the diameters agreed on were slightly less than are customarily used on the first two sizes of motors, and all of the remaining sizes were increased in diameter. It was agreed to follow the standards of The Electric Power Club on key-

ways and tapers for the armature shaft.

In the questionnaire previously mentioned by Mr. Cummins, the question was raised as to whether or not anti-friction bearings should be accepted as standard for mill-type motors. Replies indicated that those who had extensive experience with anti-friction bearings strongly favored their adoption while the majority of the replies, based on numbers, indicated that motors equipped with sleeve as well as anti-friction bearings, would be in demand. Inasmuch as the majority voted for the sleeve-type bearings, the recommendations are for a motor equipped to take either sleeve or anti-friction bearings. Mr. Cummins pointed out that if an operator will standardize on anti-friction bearings, he will be able to decrease the over-all length of the motor; that is, the difference between the brake and the pinion will be from 2 to 5 in. less than would be the case if sleeve bearings were used. Mr. Cummins also stated that it was agreed by the committee that the anti-friction bearings used on armature shafts and axle shafts must be enclosed in dust-proof capsules which are clamped in the motor end frames or axle bearing supports, as the case may be. This was required because the armature and jack shafts may be exposed to mill dust on many occasions while lying in storage, and it was thought that adequate provision should be made to protect the anti-friction bearings from dust and dirt.

In discussing the report of the Standardization Committee, J. D. Wright of the Engineering Department of the General Electric Company stated that his company was contemplating bringing out a new line of mill-type motors and for this reason was very glad to co-operate to the fullest extent with the Standardization Committee. A. J. Standing, electrical superintendent, Saucon plant, Bethlehem Steel Company, expressed his pleasure regarding the splendid co-operation shown by the different manufacturers of mill-type motors. C. S. Proudfoot, General Manager, United States Ferro Alloys Corporation, stated that at first when he heard of the steps taken by the Standardization Committee, he was not in favor of the program. However, the results outlined by Mr. Cummins looked very promising and met with his full approval.

A. M. McCutcheon, Chief Engineer, Reliance Electric & Engineering Co., stated that should his company bring out a mill-type motor in the future, they would most certainly conform to the standards recommended by the Association. He felt that the standardization program set up by the Association should be held up as a model for future work along this line. He spoke of the difficulty that had been encountered in attempting to get an agreement on standardization of general-purpose motors, and which to this day has not been effected. He pointed out that there is no trouble in actually arriving at a set standard for general-purpose motors; the difficulty lies in getting the manufacturers to agree on a definite program.

Brent Wiley of the Westinghouse Electric & Mfg. Co., expressed his gratification at the co-operation and results that had been secured by the Standardization Committee.

D. M. Petty, Superintendent, Electrical Dept., Lehigh plant, Bethlehem Steel Company, moved that the work of the Standardization Committee be made an official part of the work of the Association. This motion was carried.

Rules for Safe Operation of Electric Overhead Traveling Cranes

The following recommendations were presented before a very enthusiastic and successful meeting of the Safety Division which followed a general luncheon given to all members of the Association at the opening session.

Rules for Crane Operators

(1) The operator should be examined by a foreman or someone designated in order that his familiarity with crane parts and their uses, as well as his ability to safely operate the crane, may be determined in practice and certified to by the examiner.

(2) The operator shall enter or leave his crane at the designated places, making use of the steps or ladder provided at those locations and having both hands free. All materials too large to be carried in pockets shall be raised and lowered by means of a hand line. The hand line must not be attached to the person of the operator.

(3) No one but the craneman shall be allowed in the cage except for repairs, inspection, or instruction of new men or for safety of men working on the crane runway.

(4) The operator shall keep his crane clean and free from all loose boards, tools, bolts, or other objects which may fall on men below or may cause tripping and falling of repairmen when working on the crane.

(5) The operator should inspect his crane at the beginning of the turn, or at least once each shift, and report at once any mechanical or electrical defects, especially noting the condition of cables, limit switches, signal gongs and collector shoes.

(6) The operator shall be responsible for the proper oiling and greasing of his crane and he should report any defects in the oiling system on any part of the crane.

(7) The operator, when about to handle material with his crane, shall devote his entire attention to his work and shall pay careful attention to the following points:

(*A*) Is the hitch of proper length and is it safe?

(*B*) Is the signal given by the proper party and does the operator understand the signal? If in doubt he must not operate.

(*C*) Can the load be carried without passing over the heads of men?

(*D*) Will load clear all obstacles?

(*E*) Test brakes by means of a short lift and return of controllers to "off" position.

(*F*) Allow no one to ride the hook or load.

(*G*) If craneman discovers men on crane runway, he should stop his crane until proper protection is provided.

(8) The operator shall avoid bumping other cranes on the runway, but if he is ordered to do so, he must move the crane slowly, with regard to the safety of men working on or below the idle crane.

(9) The operator must not make side pulls unless ordered to do so by a foreman.

(10) The operator must be sure that his controllers are in the off position and switch opened before leaving the crane, and in case of failure of power the controllers must be immediately set in the off position.

(11) In case a controller sticks the operator must pull the main switch at once.

(12) While repairs are being made to the crane, the operator must stay on the job and help with repairs. If ordered to remain in the cage, he must not operate any motion unless he is told that every one is safe.

(13) When the operator is inspecting, repairing, or lubricating his crane, the main switch must be locked in the off position.

(14) In case of a fire on the crane, the operator must use the fire extinguisher provided and must notify the foreman, who shall see that the

fire extinguisher is promptly refilled.

(15) An operator must not operate his crane if he is not physically fit to do so. He should report to his foreman at once.

(16) The operator must signify his understanding of these rules and must realize that they are intended to help him safeguard the lives of his fellowmen.

Rules for Floormen

(1) Foremen when signaling to the crane operator must use the approved crane signals and above all, they must be sure that they do not confuse the operator.

(2) Floormen must be responsible for all slings, chains and hooks and for their proper use in order to make safe hitches, bearing in mind the capacity of the slings and of the crane.

(3) Floormen shall be sure that the crane trolley is centered over the lift in order to prevent swinging of the load.

(4) Floormen must adjust the slings and chains so that they will not strike them on the ground when the crane is moving without a load.

(5) Floormen shall not ride the hook or load or permit others to do so.

(6) An extra man should be in the crane cage to warn the operator when men are working on the crane runway except where approved track torpedoes are used.

In recommending the adoption of these rules, A. J. Standing, Electrical Superintendent, Saucon Plant, Bethlehem Steel Company, stated that the 16 rules composing the code were boiled down from 52 rules that were submitted by the safety organizations of the various steel companies. It was felt that the rules should be as short as possible and few in number, so that they could be readily absorbed and made use of by the average craneman. The rules are general in nature and are not intended to be arbitrary. They are applicable to all plants and special rules should be added to them to fit special conditions in the various plants. Various modifications of the rules were suggested by different members, such as provision for audible signals, testing of limit switches, method of cleaning cranes, and also a rule requiring that all maintenance men should be off the crane whenever regular operation is resumed after a period of repair or maintenance. The general membership, however, felt that these were special rules and should be covered by the supplementary rules added to cover special conditions in a particular plant. The rules were adopted in the form submitted by the committee and presented in full in the foregoing pages.

At this same meeting several addresses were made regarding safety in connection with cranes. Dr. W. P. Fisk, Chief Surgeon and Physician of the International Harvester Company, spoke on, "Physical Qualifications of a Crane Operator." In brief, he put forth the following points: (1) The age of the crane operator should be such that he will avoid the indiscretions of youth and yet not be so old that he has begun to fail. He felt the age should be between 30 and 45. (2) The crane operator should speak the language of those with whom he works. (3) He felt that considerable should be known about the family history of the operator. For example, he would want to know if there were any peculiarities in his family, such as insanity, epilepsy, and the like, and also whether he was excitable, nervous, or inclined to drink. (4) He would make his selection of crane operators from those who had already proven themselves in some department of the works rather than endeavor to pick up his operator from the labor at the gate. He also felt that the crane operator should know more about electricity than the ordinary employee. (5) Dr. Fisk pointed out that a married man was more steady than a single man, and he would prefer this type for crane duty. (6) In regard to the physical examination to which he would subject crane operators, he brought out the following points: Weight and height have no bearing on the fitness of an operator. Vision and hearing are very important. He would not accept an operator without perfect vision and would test vision for both far vision as well as near vision. The crane operator must hear everything. He should be cool-headed and his general health should be good. He stated that high blood pressure is not a dangerous condition, provided it is accompanied by intervals of low pressure. He would also examine the condition of the crane-man's heart with a view of ascertaining the possibility of collapse while on the job.

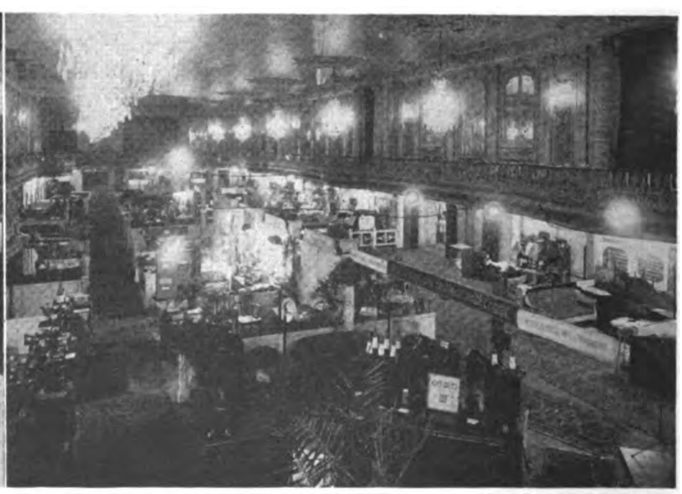
Charles B. Scott, President of the National Safety Council and Director of the Bureau of Safety serving the Insull properties, pointed out some of the work that the National Safety Council was doing and also how it was important that men engaged in safety work should keep abreast of the times and take advantage of every medium by which they could increase their knowledge on improved safety methods. He stated that co-operation is one of the most important problems confronting the safety men of today and pleaded for a co-operative interest in the National Safety Council.

As proof of the necessity for co-operation between the electrical engineer and the safety engineer he presented an analysis, made under his supervision, of some 12,000 accidents occurring during a period of several years among 50,000 employees. Of these accidents only 8 per cent were caused by electric current. However, this 8 per cent of the total accidents was responsible for 75 per cent of the total accident costs, for 75 per cent of the total lost time, and also for 75 per cent of the fatalities that occurred. Upon devoting marked attention to the 8 per cent of electrical accidents, he was able to reduce them considerably in less than one year's time.

Mr. Scott also pointed out that at least 70 per cent of the accidents that occur are due to the men who are engaged in the work. As a remedy for this, he advised first, careful selection of men who do the work; second, careful instruction to the men on how the work should be done; and third, careful and close supervision of the men. In most cases, it is the last of these factors which is overlooked and in his opinion the majority of accidents occur when this supervision is relaxed. Safety should be considered as a part of actual operation and until such is the case the rallies, posters and other propaganda do not have their full effect.

Views of opposite ends of one of the two exhibition halls used for the Iron & Steel Exposition at Chicago.

Exhibits in the second exhibition hall are shown on pages 302 and 304. A total of 76 manufacturers displayed their products at this exposition.



A. C. Cummins, Electrical Engineer, Duquesne Works, Carnegie Steel Company, pointed out some of the causes of electrical accidents that have occurred in his plant. The first cause was shocks. Many of these are due to the fact that many circuits cannot be completely isolated and killed when worked upon. New plants should be designed to take care of this point. Electric burns are due mostly to negligence and are caused by lack of instruction. A third class of accidents is due to equipment failures, such as limit switches.

In case obsolete electrical equipment is in use, improved equipment should be substituted. Two other causes of accidents are fires and explosions, which are very rare. A sixth cause of accident is lack of co-operation; his suggestion was that maintenance engineers should work hand-in-hand with the safety engineer.

Report of Electric Heat Committee

By W. P. CHANDLER, Jr., Chairman
Special Engineer, Carnegie Steel Co., Pittsburgh, Pa.

Arc Melting Furnaces—The use of arc melting furnaces in the steel industry has developed in two distinct branches: the production of ferro-alloy steels, and the steel foundry. In the case of the former, the ease with which the temperature, alloy additions, and slag compositions can be controlled, coupled with a much higher market price, allows the use of the high-priced fuel. However, except in some few special cases, large tonnage production of plain carbon steels in electric furnaces in competition with other fuel-fired furnaces, would not be very productive of dividends.

The use of the arc furnace in the steel foundry has been steadily growing. Judging from the new installations made and the continuance of existing installations in operation, the electric arc furnace is an economical furnace for the production of steel castings.

In the production of gray-iron castings it would appear as though the electric arc furnace would find its most fitting application. It is rapidly increasing in favor and has proven successful in every case that can be traced. Its adoption in this field allows one furnace to supply either iron or steel. It is possible to use scrap unsuitable for cupola practice, and at the same time reduce the cost per ton of castings by a very substantial amount.

The past 18 mos. have witnessed a renewal of interest in the possibilities of duplexing with the electric arc furnace. This year a contract has been let for the installation of a 25-ton furnace for duplexing on special steels from an open hearth for the making of ingots.

With the advent of more and more continuous molding and the introduction of permanent mold machines, there has risen a need for a more continuous supply of hot metal in quantities suitable to the output of these machines. Batch operation is usually unsuitable for these improved molding methods and various schemes of continuous pouring have been developed. In brief, they involve the maintaining of a constant bath of liquid metal with definite amounts of metal tapped at equal intervals and a like amount of cold scrap added immediately after each tap. Duplexing hot metal is particularly adaptable to schemes of operation which require a continuous delivery of metal to the pouring floor.

Induction Furnaces — The development of the induction furnace, and especially electrical equipment which will place an installation on an economical basis, offers great possibilities in the field of electrical heating. So far its development and application have been confined principally to the non-ferrous industry, the production of carbon-free ferrous alloys, and to experimental laboratory work.

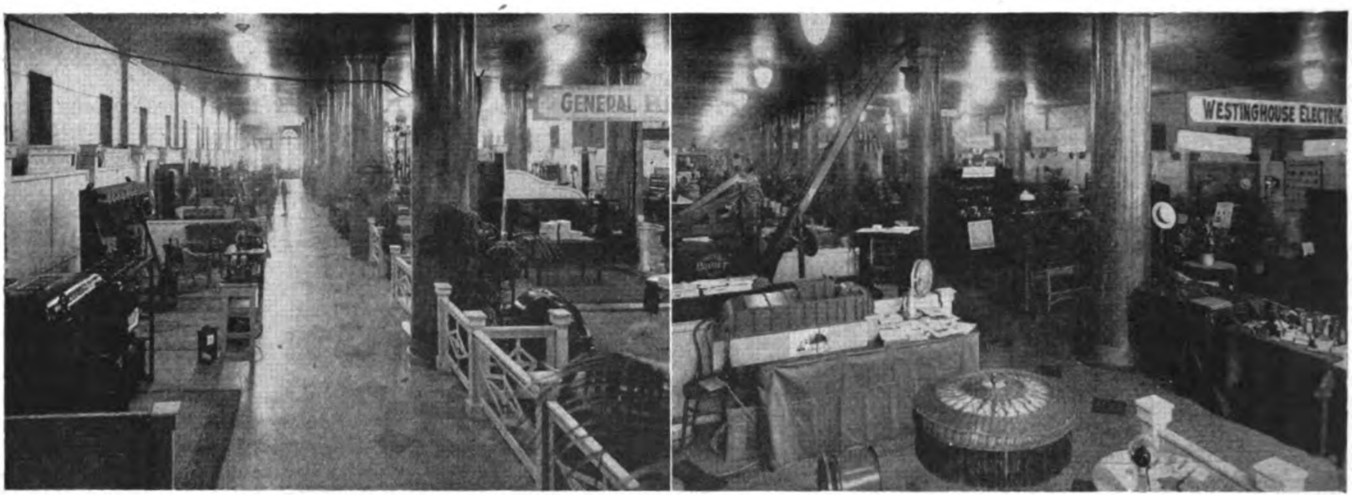
Resistance Furnaces (High Temperature Applications) — In order that the various sources of economy may receive the proper consideration from any one contemplating an installation of high-temperature resistance furnaces the following list of points is taken from statements made by users of the equipment. Due to the differential, usually in favor of liquid or gaseous fuel as against electricity, the amount of gain to be derived from secondary sources usually determines whether an installation will be an economic success or not. The following are the points of advantage as experienced by users of such electrically heated equipment:

1. Repairs are less, due to the linings not being subjected to excessive temperatures.
2. Operating labor less per ton than in the case of solid fuel.
3. Time required for heating furnace up to working temperature is less.
4. Rejections less; in some cases this statement is not true.
5. Product more uniform, due to more accurate control of temperature.
6. Construction more adaptable to automatic operation.
7. Increased electric load factor makes cheaper electric power costs.
8. Furnaces used at off-hours given power at low price.
9. Cost of current less than cost of solid fuel. In a great many cases the actual fuel costs are found to be less with oil or gas than with electricity.
10. Scaling and decarbonizing may take place if great care is not exercised.
11. The comfort of the operators is much greater, where no fumes are experienced.

The small furnace, resistance type, is finding a considerable number of applications in tool rooms for heat-treating purposes throughout the steel and other industries. Especially when equipped with certain special types of control it is well adapted to this service. The question of cost of fuel for these small furnaces is usually only a secondary consideration for quality of product and ability to duplicate results is of prime importance.

The application of such furnaces to the pipe and tube industry for the treatment of threading tools and piercing points is only one of a great number of installations.

Low Temperature Applications—The application of resistance-type electric heating to low-temperature work is wide and various. New uses for such heating are appearing from time to time and, especially in plants which are considering complete electrification, applications of electric heating are considered which would not be economically sound, except in their relation to the whole scheme. Under such headings can be mentioned the production of process steam at distant points by using immersion heaters, the heating of small outlying office buildings, shops, etc. In other cases where the differential between electric heat and other fuels is not too great, the added advantages derived from the application of electric heat to certain processes show a gain from electrification. At the Maryland plant of this company an installation was made on an electrically heated tin pot. On the tin side, 100 kw. of heating units was installed, of which 75 kw. was automatically controlled. In the beginning 25 kw. capacity of heating units was installed on the



palm oil side but it was found later that its use was unnecessary except for a short time for starting the pot. The installation was made late in December, 1925, and the operating results so far indicate that from a tinning standpoint the results are better than with gas-fired pots. Production has been increased about 50 per cent per pot and the sum of the other factors entering into operation has been reduced materially, so that the additional cost of electric heat over gas has been offset, showing slight savings in favor of the electric pot.

The application of electric heating to furnaces for drying and annealing wire and similar products is growing in favor. One such installation is used for drying acid from rods before drawing at the National Screw & Tack Co., Cleveland. Natural gas had been used previously as fuel. The electric-heated furnaces were found to have much greater capacity, three electric ovens replacing seven gas-fired ones. The capacity of the ovens has increased from 1.5 tons per hour to 5.5 tons per hour per oven. A secondary advantage obtained was the elimination of the glazed coat left on the rods dried in the gas furnace. The coating scratched the rods and clogged the dies, and its elimination in the electrically-heated oven has resulted in longer life for the dies. The cost of electric heat is greater than for gas but the increased tonnage has resulted in a lower cost per ton.

An interesting application of electric heat equipment to a galvanizing kettle was placed in successful operation early in 1925. As far as is known this is the only electric galvanizing kettle in existence. The operators of this kettle report that in comparison to the previously used coke kettle, the operation is cheaper and drossing is reduced to a negligible amount. The production has been increased, working conditions are better and because of the automatic control no attention is required.

One class of repair work which often causes trouble in a steel mill is the rebabbitting of bearings. The class of labor often employed in this work is not of the best so that accurate control of gas-fired furnaces is not obtained. The results under such circumstances can hardly be much better than they are. The installation of electrically heated pots at one steel mill has been proven economical and very satisfactory. A much better product and much greater capacity is being obtained from the same crew of men with no increase in the fuel bill.

In one shop four 1,500-lb. soft melting pots are used on large railway motor bearings and axle shaft shells. Each pot is controlled by a pyrometer, set according to the particular composition being poured. One pot is used only for tinning purposes. Tin-base babbitt is for the most part used on railway bearings because of the severe service conditions.

This installation has been in practically continuous operation since September, 1924, and has been shown to many visitors interested in this particular class of work. The operators are very pleased since changing from gas-fired pots. They give the reasons as: Better working conditions through elimination of fumes and lower temperature radiated from the pots, as well as marked improvement in the quality and texture of the bearings produced, because the temperature is controlled within a few degrees of the correct pouring temperature for the alloy. The watchman starts the pots at 5:00 a.m., which brings them up to the correct temperature by 7:00 a.m. The total installed capacity is 100 kw. operating at 220 volts.

Electric Arc Welding in the Steel Industry—Electric arc welding provides a satisfactory means of welding without preheating, and in many cases renewal of parts made of grey iron. Work that has been done in this direction includes repair of blowing engine cylinders which have cracked in service, large gas engine cylinders which operate on blast furnace or producer gas, crane engine cylinders, locomotive engine cylinders, pump cylinders, steam separators and steam traps. The saving in work done by the electric arc welding process on material of this kind is usually very large. Spare castings are usually not carried for parts of this nature and a delay of one to six weeks occurs between the time the casting is ordered and the time it arrives on the job. In many cases a machining operation to get the casting ready to use also causes considerable delay. Welding with the electric arc in place of caulking is an important application in steel plant work. Jobs of this nature are found on gas lines carrying producer gas or blast furnace gas, on blast lines, on the blast furnace shell itself and on stoves. After riveted plate construction, such as the above, has been in service a while the riveted joints become loose and a considerable amount of leaking results. In order to redrive the rivets, it is necessary to practically tear down the structure. Welding on this work has been found to cost slightly less than caulking with an air gun.

Electric arc welding finds a wide field of usefulness in the repair of broken and worn steel castings.

Under this classification come yokes, truck frames, trunnions and cinder ladles, hot metal ladles, ingot buggies, steel castings on gas producers and stoves, electric cranes, trucks, and manipulator castings.

Electrically welded stacks for the open-hearth, sheet mill, and miscellaneous smoke stacks about the mill, are better and last longer than ordinary riveted stacks.

Steam lines around a steel mill are a source of considerable amount of waste and may be a cause of shutdown. The large steam lines have cast steel flanges screwed on the pipe. It is the practice of several plants within the writer's experience to electrically weld the cast steel flange to the pipe, in addition to the threading. It appears that the threaded joints eventually leak and the wire drawing of the steam and corrosive action weaken the pipe at the thread, causing waste and liability of failure of the steam line, with attendant loss of life and shutdown of the plant. This is another case of insurance against shutdown by the use of electric welding.

Every steel mill has a large number of crane motors and there is an extensive application of electric welding in building up the bearing area of the armature shaft, the pinion seats and straightening out keyways which have been damaged. This work falls in the electric welding field due to the economical application of metal through the use of electric arc equipment.

There is a considerable time saving in the use of electric welding for the above purposes, and there is a saving due to the fact that a new shaft does not have to be machined for the job. The elimination of pressing the old shaft out and new one in, is also an important item.

It is quite pleasing to note the distinct advance welding equipment manufacturers have made in the line of stable arc equipment. The arc characteristics alone many times spell the difference between a failure and a successful weld. Realizing the importance of good equipment, good materials and operators, electric arc welding is the most powerful and increasingly useful tool a maintenance superintendent has.

When properly selected, organized and instructed, welding operators will do good, conscientious work, and will do justice to electric arc welding, but let the operator be dissatisfied, untaught and trying to "get by," nothing can be hoped for. So it is, then, of the utmost importance to have specially selected men taught to handle the electric arc by an expert in welding.

Use of Electric Industrial Trucks and Tractors in Iron and Steel Industry

By HAROLD J. PAYNE
The Society for Electric Development

If we analyze the possibilities for continuing to cut production costs in various branches of industry, we find that it is very often in improvement of transportation methods that the most promising possibilities exist for savings. This may be partially accounted for on the basis of two facts: (1) That in the past, gaps not capable of being filled by heavy, high-capacity equipment have not received their fair proportion of attention and, (2), that up to the time when the cost of labor began to soar, boards of directors were inclined to favor appropriations for major changes in process equipment rather than relatively insignificant budgets for patching up the leaks in faulty transportation operations, when recommendations were made regarding savings that could be obtained.

The electrical industrial truck and the tractor represent one of many types of equipment for meeting materials handling problems effectively.

The industrial truck is being successfully applied to transportation problems in the older types of blast furnaces. The quantity of material handled at a modern blast furnace is very large. A furnace turning out 400 tons will have to be fed every 24 hr. with approximately 800 tons of ore, 400 tons of coke and 200 tons of limestone, or a total of 1,400 tons of solid materials.

From the material handling standpoint there are three types of furnaces: (*a*) hand-filled elevator furnaces; (*b*) skip-filled furnaces without larry car equipment and, (*c*), skip-filled furnaces with larry car equipment. At the first two types of furnaces, industrial trucks may be used to advantage in speeding up the charging, reducing the labor expense, and relieving a shortage in a very specialized type of labor.

In the earlier types of elevator furnaces the charges are handled in two-wheel buggies. These buggies are pushed from the storage bins to the elevator at the furnace and then lifted to the charging stage, where two men empty them into the charging bell. One of these buggies loaded with ore weighs from 1,400 to 1,600 lb. and the man who pushes this load comes under the heading of selective labor. He is especially trained for this very heavy work and his muscles have become hardened to it. This class of labor is very scarce and it is very difficult to break in new men.

Among others, five furnaces of the Carnegie Steel Company have been equipped with trucks and a brief description of the work being done will supply useful data for working out similiar problems. At the time it was equipped, furnace No. 2, at Bellaire, was of the hand-filled type first mentioned. Between the wheels of each of the old buggies, a sub-frame made of angle iron was built. This frame was placed about 12 in. from the ground, allowing sufficient clearance for handling with a standard elevating platform truck. The buggies were picked up at the elevator, carried to the ore pocket and returned to the elevator. When hand buggies were carried by the elevating platform trucks, however, a total of six trucks with 13 operators is said to have replaced 54 specialized laborers.

The rebuilding of open hearth furnaces, an operation usually necessary annually or oftener, involves handling 300 tons of refractories for a 50-ton furnace. In many plants brick are now wheeled from car or storage to the furnace, thus involving a large amount of unnecessary handling. Lift trucks handling brick on skids in the plants where they are made are earning $8,000 to $12,000 a year over hand wheeling costs, and it is our belief that a corresponding saving is possible in open hearth plants where a large number of furnaces is operated.

One of the most profitable uses to which the industrial truck has been put in the steel industry is the handling of rods and flat strip, including band and hoop stock. Several plants are using ram or crane trucks

for this purpose, while others use tractors with trailers or lift trucks with skids. The final choice of equipment depends quite largely on individual plant conditions.

The difficulties involved in handling these materials are generally appreciated. A prime consideration involved in the selection of equipment for this work is flexibility. Wire as it comes hot from the mill is heavy, bulky and awkward to handle thus making it necessary to meet a set of special conditions.

The crane truck has been found by several users to be well fitted for unloading, as well as for loading cars or other vehicles with rods or wire. A large manufacturer of nails, rivets, etc., found that such a machine saved 80 per cent over the cost involved in handling wire manually. Formerly it was the custom to handle bundles of wire weighing 150 lb., but with the aid of mechanical equipment of this kind, it was found possible to handle 300-lb. bundles without difficulty. Consequently, every department in the plant has been affected.

Handling of pipe fittings and small iron or steel sundries is occasionally improved by the use of a magnet sling from a crane attached either to a low-lift or straight platform truck. Power is supplied from the battery of the truck and the magnet is used for loading or unloading as is commonly the case, on a larger scale, in handling pig iron.

The storing of cases and kegs in warehouses, prior to shipment, constitutes an operation that is wide open to lost motion. The tiering truck, however, has come into favor in many plants for doing this work. The Bethlehem Steel Co., for instance, is reported to be using seven machines in its storerooms at the Bethlehem plant. Carrying its load of 2 or 3 tons to heights of 8 ft., this machine, having all of the flexibility of an ordinary low-lift truck, is often able to make large earnings. From eight to ten men per unit appears to be average experience with this type of equipment in warehousing.

The handling of black sheet, plate, etc., has perhaps received more attention on the part of manufacturers of electric truck equipment than any other series of operations in this industry. For some jobs, where the sheets are large, the elevating platform truck with skids is used; on others the tractor-trailer method has worked out satisfactorily; on at least one job the crane truck with a special cradle attachment is used for handling. When tinplate is the commodity to be transported, several specially-designed trucks become available, two of which have been designed particularly for handling this commodity.

Some time ago a survey was made to ascertain the average cost of handling tinplate, with hand trucks, at hourly or piece rates, manually as against handling with a fork-type truck. These figures are on the basis of 100 base boxes.

	Hand Trucks	Power Trucks
Handling loose tinplate in and about plants.......	14-16c.	4½c.
Handling loose tinplate from plant to car or vice versa	16-19c.	8½c.
Handling boxed tinplate in and about plants.......	12-14c.	4½c.
Handling boxed tinplate in and out of cars.......	15-17c.	8½c.

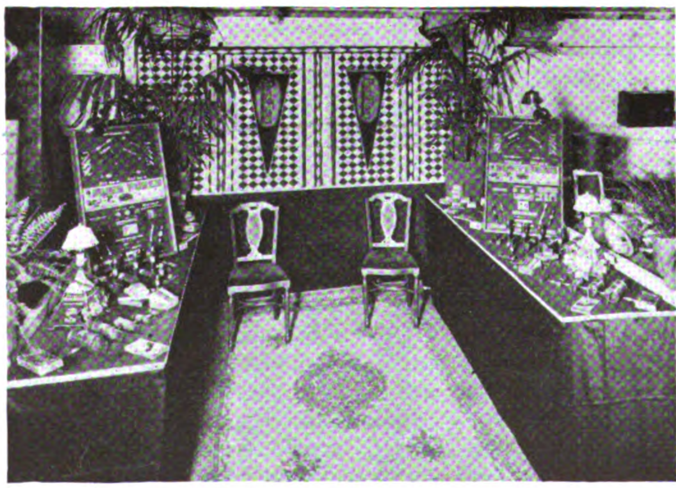
This same survey points out that definite possibilities exist for lowering the per ton cost of packing; this could be decreased as much as 50 cents per ton by replacing the average 1¾ base box holding 175 lb. with a box of the same sheet size to hold a ton. Should this idea prove sound and be generally adopted, with 1,400,000 tons of tinplate produced annually, a cut of $700,000 from this source is not at all impossible.

Throughout this account references have been made to savings in terms of men per unit or in terms of net earnings. One company that builds electric industrial trucks surveyed 15 plants in the Pittsburgh district about three years ago—plants that use one or two electric units and found the following averages to hold:

Maximum saving in per cent per plant..	79
Average saving in per cent per plant...	52
Maximum number of men saved per plant	18
Average number of men saved per plant	7½
Maximum saving per year on investment	345
Average saving per year on investment	270
Maximum saving in per cent per unit...	75
Average saving in per cent per unit....	29

It has been difficult to isolate average total fixed charges per unit, in various operations, but the most reliable figures obtained show that even in heavy service this charge rarely exceeds 60 cents per hour and that 50 cents is a reasonable average on all installations except those in which unusually difficult operating conditions have to be met.

In concluding this summary of the industrial electric truck applications in your industry, a few unusual applications of the equipment should be pointed out. The crane truck has proven especially valuable in the service of maintenance departments—each unit saving 35 men in one plant. Pipe laying was expedited in a Pittsburgh steel plant through the use of such a unit. At another plant a basket in which the electrician works while trimming arc lights is handled by a crane truck. A high-lift truck equipped with a plow has proved a valuable means of clearing narrow runways of snow in winter. Smaller plants use the electric industrial truck to spot freight cars in the absence of a locomotive. Heat-treating plants substitute long forks for a straight platform on the high-lift truck and decrease the labor required



for charging carbonizing furnaces by 15 men per unit employed.

The advantages gained through the application of this or any other equipment designed for similar purposes depends not only upon direct saving in payroll expense but also, to a very large extent, upon other factors. An automobile manufacturer increased production more than five times in a manufacturing area that was increased only 33 per cent and with a decrease in storage area of 25 per cent. A very large concern building agricultural implements has stated that one of the principle savings made comes from decreased inventory costs through keeping material in platform containers at all times. Many plants have experienced a decrease in labor turnover as a consequence of the substitution of labor-aiding electrics for backbreaking hand trucks.

Yard Switching and Mill Transportation

By W. B. POTTER and G. H. SHAPTER
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Yard switching is characterized by short movements and with considerable time lost for coupling and at switches. From observed operations the time in motion may be assumed as one-half to one-third of the time in service. While the maximum speed may be 10 miles an hour or more, the average speed is much less and the schedule speed will usually be found around 3 miles per hour, or about one-half the 6 miles per hour which is the conventional schedule commonly assumed.

The average power requirement for yard switching is considerably less than is sometimes appreciated. While the tractive requirements are high the schedule speed is so low that the average power used in performing the schedule may range from 30 to 60 kw. The maximum and average power while in motion will be considerably higher than these figures, depending upon the acceleration.

The steam locomotive is so generally used and has been so successful in switching service that there should be some good reason for considering other types of motive power. Expediting the switching movements, more hours available for service, lesser number of locomotives needed, lower maintenance, reduction in cost of fuel and the elimination of smoke, are some of the reasons which justify this consideration.

The Diesel or oil-electric locomotive is a comparatively new type of motive power, as regards its application to regular service. In effect, it is an electric locomotive deriving its power from an oil engine located in the cab, instead of from a trolley wire or third rail.

Freight yard switching is being successfully handled with 60-ton locomotives equipped with 300-hp. engines. Although 300 hp. is considerably less than the power rating of steam locomotives used in this kind of switching, it appears that these oil-electric locomotives handle the switching more expeditiously than do the steam locomotives having equal weight on the drivers.

The relative fuel consumption of oil-electric and steam locomotives in switching service can perhaps best be given by comparing the gallons of oil with the tons of coal. The records obtained indicate that 20 to 25 gal. of oil are equivalent to a ton of coal, so that with oil at 5 cents a gallon, the comparative cost of fuel on this basis would balance at $1 to $1.25 per ton for coal.

The gas-electric locomotive is similar to the oil-electric except as to the type of engine and character of fuel. The electric drive is advantageous with the gas-electric for the same reasons mentioned for the oil-electric. This locomotive is somewhat less expensive because of the lower cost of the power plant equipment, but the fuel expense is increased because of its higher cost per gallon and the lower fuel economy of the gasoline engine. The quantity of fuel for a given service will be from one-half to two-thirds more than for an oil engine, which with the ratio of 3 to 1 for the relative cost per gallon means a difference in fuel cost of about 5 to 1.

The storage battery locomotive with engine auxiliary is a combination in which a gasoline or oil engine, of sufficient power to provide the average demand, maintains the charge in the battery. The battery serves as a reservoir of energy delivering power at intervals whenever the demand exceeds the output of the engine. The power supplied by the engine further permits a reduction in the amount of battery required. There are places where the storage battery locomotive will best serve the purpose, but where it may be inconvenient to take it out of service for the purpose of charging.

The storage-battery locomotive may well be regarded as the best of the station-charged units. It is fully capable of handling yard switching and is as responsive to the demand as any electric motor locomotive. Its duty cycle is necessarily limited, however, to the amount of battery provided. Where the battery is adequate the performance is very satisfactory, but like all station-charged locomotives it must receive more energy than it delivers. Including the losses in the charging equipment usually required, the overall electrical efficiency will not be far from 55 per cent.

The electric locomotive is unquestionably the most powerful type of locomotive that may be used, and is the most effective of all to expedite switching movements. Its tractive power is limited, as in all cases, by the weight on the drivers, but the speed at which this tractive power may be obtained is only a question of motor capacity. These locomotives require a contact system throughout their range of operation and a power supply of suitable voltage. Either an overhead trolley construction or third rail may be used with equal success, so far as delivering the power is concerned.

The electric locomotive with storage battery auxiliary provides a means for entering upon certain tracks, as within buildings, where a trolley or third rail would not be permissible. The storage battery receives its charge while the locomotive is taking its power from the trolley, and so is in condition to supply power whenever it is needed. A comparatively small battery will usually be sufficient for this purpose.

Following is a brief description of some of the more common applications for electric and storage-battery locomotives in steel mill service.

The by-product coke oven is a comparatively recent development which includes all the operations through which coal goes when introduced into the ovens until it is finally placed on the cooling wharf.

An electric locomotive is particularly well suited to meet the special requirements for handling this coke. The usual type of coke oven locomotive is a 20-ton single truck machine especially designed with respect to the location of the operator. The operator is in an elevated cab where he has a clear view of all the operations which this locomotive must perform.

One of the most important of steel mill switching operations is the handling of hot metal in ladle cars from blast furnaces to Bessemer converters, mixers, or open hearth furnaces. The use of electric locomotives for handling ladle cars involves special consideration of the method of supplying power to the locomotives. Tracks run into the building underneath furnaces and over numerous crossings, so that it is practically necessary to design some special form of collector trolley device. Third rail shoes must be located far enough away from the main track to clear the casting bodies of the ladle cars. In spite of these handicaps numerous installations have been made. Some kind of self-contained locomotive is seemingly best adapted to the handling of hot-metal ladle cars, except when it is possible to provide a means of contact which is not too elaborate and expensive.

The handling of materials for open hearth furnaces is another very important operation in the steel mill. It is desirable to use a storage battery for this work because the tracks are usually inside of the building for at least 800 or 900 ft. in front of the ovens.

Many open hearth furnace buildings are so located that the scrap material must be handled up relatively heavy grades and around sharp curves before trains can reach the furnace floor. In general 20- to 25-ton locomotives would be the most suitable units for this duty. Cars for open hearth work are usually very crude in design and bearings are difficult to lubricate, so that car friction is quite high. It is likely that a combination trolley or third rail and battery locomotive would be found most suitable from an electrical point of view for this class of work. With the battery unit it would be possible to enter the building on the charging floor without the use of trolley wires or third rails. It would also be possible to operate the locomotive at the scrap pile without the use of third rails.

Economics of Steel Plant Railroad Electrification

By O. NEEDHAM and DAVID C. HERSHBERGER
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For the purposes of this study, we have assumed a typical steel plant having a narrow gage containing 9 miles of track, and a standard gage comprising 40 miles of track. The narrow gage railroad system is distributed around the open hearth furnaces and the mills in close proximity to the buildings, and is confined to a relatively small area and trackage.

This system employs small steam locomotives at present, and these in relatively large numbers considering the work to be done. The standard gage railroad system is also distributed throughout the plant, taking care of the transportation involving the use of standard railroad cars, ladle and slag cars, etc. The tracks comprising the standard gage systems are mostly located on the outer sections of the mill area, with many branches running into the various mills and by the open hearth buildings. The character of the work performed is diversified, but all of it comes under the class of switching service.

This study is confined to the two most promising systems of electrification for steel mill yard work. These two systems are as follows:

(1) The 250-volt, direct-current, third-rail system.

(2) The Diesel-electric locomotive.

It is generally recognized that certain sections of a narrow gage railroad system cannot be equipped with a third rail. One of these locations is in the open hearth pit where it is difficult to maintain the present track rails on account of the great weight they are subjected to at times in supporting the ladles and masses of steel resulting from clearing the ladles of "skulls" and sometimes from the relatively large masses of steel resulting from defective pouring. Under these conditions the installation of a third rail, which is located higher than the running rails, is impracticable. Another location is in the open hearth scrap yards, where steel is being transferred from standard gage cars to narrow gage cars. On the other hand, there are many sections of the narrow gage system which may easily be equipped with third rail construction. It is evident, then, that combination locomotives are required for part of the work, while other sections of the system can be served with ordinary third rail locomotives.

The combination locomotive should be a combination third rail and storage-battery type locomotive. It is preferable to make the transition from third rail to self-propulsion when going to sections of the track not having third rail, with minimum effort and manipulation of control. It is estimated that the following narrow gage electric locomotives would be required to replace the 21 narrow gage steam engines now in service:

5—50-ton combination third rail and battery-type locomotives.
5—25-ton combination third rail and battery-type locomotives.
6—25-ton third rail type locomotives without battery.

Past experience in steam railroad electrification and in the electrification of steam railroad terminals justifies a material reduction in the number of locomotives.

Experience has shown that an electric locomotive with a given weight on the drivers can do more work than a steam locomotive having the same weight on the drivers or, conversely, a given steam locomotive can be successfully replaced by an electric locomotive having less weight on the drivers. This is because the motors of an electric locomotive give a uniform tractive effort, whereas the cylinders of the steam locomotive provide a variable tractive effort. This uniform tractive effort minimizes the tendency to slip the wheels on the rails when accelerating heavy loads.

The following standard gage electric locomotives are required to replace the 15 standard gage steam locomotives now in use.

8—45-ton third-rail type locomotives.
4—80-ton third-rail type locomotives.

Upon first thought it would appear that the Diesel-electric locomotives should make a very favorable showing in steel mill yard service. So far as its performance is concerned, the

locomotive is well adapted for this service, but on account of the relatively high investment costs there is not so promising an outlook for the Diesel electric as for the third-rail type of locomotive, as will later be shown in this paper.

This type of locomotive may be put in service where the steam locomotives are now operating, without the necessity of erecting a third rail and, furthermore, may be placed in service a few at a time.

It is estimated that the following Diesel-electric locomotives would be required to replace the 21 narrow gage steam engines.

12—25-ton, Diesel-electric locomotives.
5—50-ton, Diesel-electric locomotives.

The following Diesel-electric locomotives are estimated as being required to replace the 15 standard gage steam locomotives.

9—50-ton, Diesel-electric locomotives.
4—80-ton, Diesel-electric locomotives.

In the accompanying table are given comparative operating and investment costs for displacing present steam locomotives by third rail or Diesel-electric locomotives.

The return on the investment shown in the table on this page is the minimum to be expected.

A comparative study of transportation systems for new steel plants places electric operation in even better position than where steam locomotives are now in operation. This is brought about by the fact that new steam locomotives are more expensive and carry a higher total fixed charge than do old engines. The result is that the return on the investment is very satisfactory as shown in the table and justifies electric operation as compared to steam.

The tables included in this paper show the worst conditions and give the minimum return that can be expected from electrification. There are a number of possibilities that could be taken into account that would improve the savings shown by either the 250-volt third rail locomotive or the Diesel-electric.

The 250-volt, direct-current system, employing third-rail type locomotives, is the most economical system of transportation for steel plant yards. The return on the investment, as compared with steam operation, is excellent and fully justifies the displacement of steam by electric motive power. A number of partial installations of this type are in operation with excellent results.

The Diesel-electric locomotive occupies second place in point of operating economy and return on investment as compared with third rail locomotives. The future of this type of locomotive is very promising and an extensive application of this type of motive power is anticipated.

New steel plants should employ electric motive power from the beginning rather than start with steam with the idea of changing over to electric later. The difference in investment costs is so quickly eliminated by the economies of electric operation as to leave no doubt as to the course to be pursued.

The steel plants cannot afford to continue to purchase new steam locomotives to replace worn-out units. The change-over to electric operation can be made in sections and a progressive program of electrification put through without heavy expenditures at any one time.

The working conditions would be improved by the elimination of smoke, dirt, and noise from the operation of steam engines.

The electric locomotive, receiving its power from a conductor, is the most reliable unit of motive power in existence. This has been fairly demonstrated in a large number of electrifications, some of which have been operating from 20 to 30 years. The third rail type locomotive has desirable features of operation that will be difficult for other types to equal. It is quickly made ready for service and its power is not limited by any local power plant or the locomotive itself for the reason that it has the steel plant power system behind it. It can handle heavy loads at moderate speeds and its general performance recommends it over other types of locomotives when a suitable conductor system can be installed.

Finally, it may be accepted without doubt that the complete electrification of steel plant yards would result not only in very large economies of a direct nature, but also in indirect benefits which cannot be evaluated.

In discussing the paper on "Economies of Steel Plant Railroad Electrification," W. P. Potter, Chief Engineer, Railway Dept., General Electric Co., said that Mr. Needham was conservative in determining the number of electric locomotives required to replace a given number of steam locomotives now in service. Mr. Potter felt that only 80 per cent of the number of electric locomotives mentioned in Mr. Needham's estimate would be actually required, thereby greatly increasing the return in favor of the electric locomotive as compared to the steam locomotive.

Considerable interest was expressed in the oil-electric locomotive by R. S. Shoemaker, Superintendent of Electrical and Mechanical Depts., American Rolling Mill Co. He believed, however, that an oil cost of 5 cents per gallon was lower than could be obtained at most steel plants. Mr. Hershberger of the Engineering Dept., Westinghouse Electric & Mfg. Co., replied that in the paper presented jointly by Mr. Needham and himself, an oil cost of 6½ cents per gallon had been used as being more representative of oil costs at the majority of steel plants.

Comparative Operating and Investment Costs for Steam, Third-Rail and Diesel-Electric Locomotives

When Displacing Present Old Steam Locomotives

	Third Rail Locomotives	Diesel Electric Locomotives	Present Steam Locomotives
Operating cost	403,155	437,450	786,900
Fixed charges	179,500	277,800	7,650
Total annual charge	582,655	715,250	794,550
Yearly saving over steam	211,895	79,300	....
Net investment	1,298,700	1,821,000	382,000
Per cent return on net investment	16.3	4.35	....

Comparison with New Steam Locomotives

	Third Rail Locomotives	Diesel Electric Locomotives	New Steam Locomotives
Operating cost	$403,155	$437,450	$786,900
Fixed charges	179,500	277,800	116,800
Total annual charges	582,655	715,250	903,700
Yearly saving over steam	321,045	!88,450	....
Investment	1,329,700	1,852,000	777,600
Per cent saving on investment	24.2	10.1	....

Some reasons why

Low Power Factor Causes Trouble and Expense

in industrial plants, with a discussion of the causes for it, methods of measurement, and effect on charges made for electrical energy.

THIS IS the first of a series of articles in which the practical problems that revolve around the power factor of the distribution system in an industrial plant will be discussed. In this article Mr. Holston tells in a simple and understandable way what power factor is, shows why low power factor is undesirable from an operating standpoint, and discusses the relation of power factor to the price that the consumer pays for the electrical energy he uses. In succeeding articles that will appear in later issues of *Industrial Engineer*, methods of improving power factor, both with and without the use of special equipment designed for that purpose, will be described.

By JAMES B. HOLSTON
Commercial Engineer, Wagner Electric Corporation, St. Louis, Mo.

POWER factor is a much talked of "will-o'-the-wisp" about which there are many misconceptions and a rather widespread lack of accurate information. Many power companies base their rates upon power factor, but the reasons why they penalize customers who have a low power factor and give a bonus to those who maintain a high power factor may not be entirely clear.

In the case of industrial plants that maintain their own generating equipment, the engineers frequently take the stand that low power factor causes no bad effects and need not be considered. Further information in regard to power factor—regardless of whether the electrical energy used is purchased or generated—may clear up some misunderstandings and help to shed some light upon this phase of power use.

Probably the most satisfactory way to explain the term "power factor" is to carry through the analogy of electricity and its manner of operation in a distribution system to the flow of a fluid in a system of piping. The following simile has been used, in part, by R. H. Rawll in Power Factor Booklet, published by the Electrical Apparatus Co., London, England.

Power stations are erected to force or pump this fluid to the consumer's premises and, if the switches are closed, it will flow through the various connected appliances, giving up its energy in the form of mechanical power, light, heat, and so on. After the electricity (as the fluid will now be called) has done its work it returns to the power house, just as in a hydraulic plant, after the water has passed through the power presses, rams, or other equipment, it flows back to the force pumps, where it is again sent out with renewed pressure. Now, in order to operate electrical machinery in a distant factory, a certain call for electricity is made on the power house and cables are laid to convey this current. But some electrical apparatus, especially induction motors, has the unfortunate knack of utilizing only a certain proportion, say 0.80, of the current flowing through it. Such an installation would have a power factor of 0.80 or 80 per cent. *It must be understood that this does not mean that 80 per cent of the power supplied is being usefully employed, while the remainder goes to waste.* Exactly the same amount of current returns to the power house as left it on the outward journey, 80 per cent of it having given up its energy and the remaining 20 per cent returning unused.

The greater the amount of current to be transmitted, the larger must be the cable through which it flows, just as in a water supply system the greater the amount of water required to flow through a pipe the larger must be the diameter thereof. This means that a cable of larger size would have to be put down to supply a consumer having low or bad power factor—with a large amount of "idle" current flowing—than would be necessary if the power factor was high or good; that is, with very little idle current present in the cables.

The detrimental effects of bad power factor are not confined to the cable systems, but may also be noticed in the generating equipment at the power house. An electric generator capable of turning out 5,000 hp. can deliver only 4,000 hp. when connected to a load having a power factor of 80 per cent, 20 per cent of the current being idle and being returned to the power house, having done no work. Consequently, larger generators have to be installed, with their attendant larger overhead charges, if the power factor is bad.

Thus it is seen that if the power factor—which may now be defined as the *ratio of useful current to the total current flowing*—of a system is raised, the following economies are effected, by the power company if power is purchased, and by the consumer if it is generated;

(1) Smaller cables and switchgear can be installed for a given load or, conversely, more consumers can be supplied by or more equipment can be connected to, a given cable.

(2) Owing to the decreased amount of current flowing in the cables the "electrical friction" or transmission losses are reduced.

(3) Less generating equipment with its necessary switchboard connections and attendance is required for a given load; therefore, there is less capital expenditure required.

(4) Each generating set can be run under such conditions that it will deliver its maximum output of power, at maximum efficiency.

There is also a considerable advantage from the technical point of view, in that when the power factor is high the absence of a large amount of idle current doing no work in the system renders the control of such a system much easier. High power factor and good voltage regulation go hand in hand, as well as do low power factor and poor voltage regulation.

Thus, it is seen that in the case

of two consumers on the lines of a central station, each using the same amount of power, the one whose system operates at low power factor is actually costing the power company far more than does the customer with the higher power factor; therefore, in common fairness they should be charged for power on a scale that varies with the power factors of their respective systems.

Reliable estimates place the amount of capital tied up in central station equipment in this country on account of low power factor at a figure approximately equal to the gross annual revenue. In 1924 this revenue was in the neighborhood of $1,350,000,000 and was derived from $6,600,000,000 of capital invested. This fact may explain the increasing interest of operating companies in power factor correction. Of course, if this tremendous investment is released, or even part of it, the result will eventually be a lowering of power rates.

Two important considerations that affect the power factor question from the standpoint of the consumer, regardless of whether power is purchased or generated in his own plant, are transmission losses and voltage regulation. With low power factor the transmission losses are excessive and the regulation is poor. Both of these factors add to the cost of power, for transmission losses show directly on the kilowatt-hour meter and poor voltage regulation causes reduced efficiency on the part of all other electrical equipment in the plant, therefore showing up indirectly in increased cost of power.

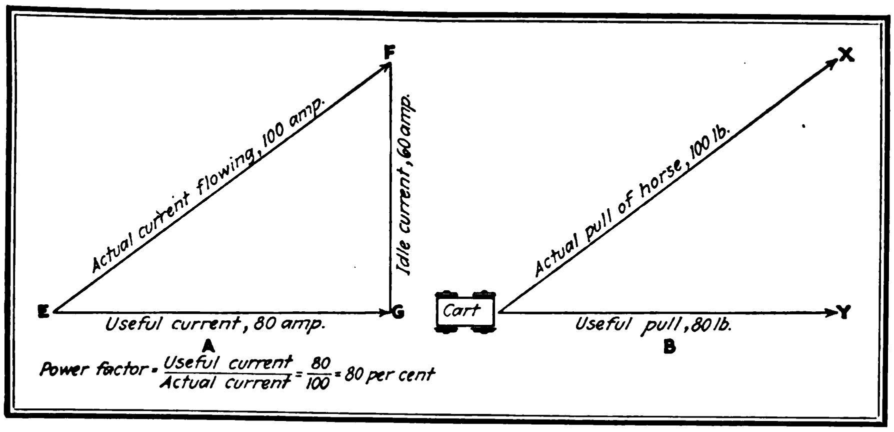
Transmission losses vary directly with the square of the current flowing; the total current is inversely proportional to the power factor: Hence, the losses vary inversely as the power factor squared. With 3 per cent loss at 100 per cent power factor the loss at 70 cent power factor is 6.1 per cent, and is 12 per cent at 50 per cent power factor.

A reduction of only 10 per cent in voltage on an induction motor may result in an efficiency of several points below that for rated voltage. Furthermore, power is a function of the product of voltage and current and for the same power as at full voltage a reduction in voltage means an increase in current, with a resulting increase in transmission losses. The "slip" of induction motors, which is the percentage by which the actual speed of the motors falls below the theoretical speed, increases with reduced voltage and where the motors are used to drive machines requiring constant and maintained speeds this reduction of voltage may prove serious.

These two factors deserve careful consideration in laying out any electrical distribution system. If it is practicable to do so, power factor correcting equipment should be installed on each of the various feeders to reduce transmission losses and improve voltage regulation thereon.

It is not the purpose of this article to deal with the methods used for power factor correction, but the four general types of equipment used may be mentioned and discussed briefly. Synchronous motors, combination synchronous-induction motors (the Fynn-Weichsel type), static condensers, and synchronous condensers may be used, each type of corrective equipment having its field of application, depending upon the particular conditions. Generally it is more economical to use either the first or second methods, as these motors replace low power factor induction motors which, if they were not removed from the lines, would have to be taken care of by additional capacity with either of the two latter methods. Static condensers may be best under certain operating conditions where power factor correcting motors cannot be used. The installation of synchronous condensers in industrial plants is seldom justified on account of the high operating costs in the comparatively small sizes required. However, central stations find use for them in large sizes where the initial investment per unit of correction is lower and the power required to drive them can be supplied by the excess generating capacity at very low cost.

These diagrams show the analogy between power factor in an electrical circuit and the use factor of a mechanical force.



For the purpose of explaining the fundamental conceptions of power factor an analogy has been given between the flow of a fluid in a system of piping and the flow of electricity in a distributing system. In dealing with practical problems such as are encountered when estimates are made of the size of corrective equipment required, or when it is desirable to check power factor measurements or calculations, it becomes necessary to use a mathematical representation of actual conditions. For this purpose a right-angled triangle is used such as is shown in diagram *A* of the illustration. The longest side, *EF*, of this triangle represents the actual current flowing. As shown, the useful current is only 80 per cent of this; hence the power factor is 80 per cent, since power factor has already been defined as the ratio of useful current to the total amount of current flowing.

The physical explanation of this is illustrated by diagram *B*. Assume that a horse pulling in direction *X* is attached to a cart which has the wheels set to move in direction *Y*. With an actual pull by the horse of 100 lb., it is apparent that only 80 lb. are available to pull the cart in direction *Y*. By making use of the same reasoning that power factor in an electric circuit is the ratio of useful to actual current, we might say that the "power factor" of the horse is the ratio of useful pull to actual pull, or in this particular case, 80 per cent. If the total current, 100 amp., in diagram *A* were all useful, the power factor would be 100 per cent, and if the horse pulled its full 100 lb. in direction *Y* his power factor would also be 100 per cent.

Where the power company has a rate that involves power factor it is necessary for them to make some

sort of measurement to determine just what the power factor is in a given case. The use of a meter to measure and record power factor directly is not practicable for small systems on account of the high cost and complexity of such an instrument. It is customary, therefore, to measure the useful current or power (which is always done whether there is a power factor rate or not) and the so-called "idle" or useless component. In diagram *A* this component is the side *FG* of the triangle. Then by a simple calculation power factor is determined from these two readings. This method is based on the use of two standard, polyphase watt-hour meters, one of which may be the regular service meter connected in the usual manner. The other meter, which is identical with the first one, is connected to a so-called "phasing transformer" to give the 90-deg. displacement, as between the lines *EG* and *FG* in diagram *A*.

In order to calculate power factor from the readings of the first or kilowatt-hour meter and the "idle" or reactive meter, as it is generally called, it is only necessary to make use of a simple mathematical theorem which states that the hypothenuse of a right triangle is equal to the square root of the sum of the squares of the other two sides. Thus in diagram *A*,

$EF = \sqrt{80^2 + 60^2} = \sqrt{10,000} = 100$, and, Power factor $= EG \div EF = 80 \div 100 = 0.8$, or 80 per cent. Therefore, if at the end of the month the kilowatt-hour meter reads 20,000 and the reactive meter 25,000, the power factor is found as follows:

Power factor equals $20,000 \div \sqrt{20,000^2 + 25,000^2} = 20,000 \div 32,020 = 62.5$ per cent.

In order to avoid making these calculations each time, the accompanying table has been prepared, showing the power factor corresponding to the various ratios of the reactive to the kilowatt-hour meter readings. Thus in the example just cited, Reactive hours $\div$ Kilowatt-hours $= 25,000 \div 20,000 = 1.25$. Reference to the table gives a power factor of 62.5 per cent for the ratio of 1.25.

The "kilowatt hour-reactive hour" system of power factor metering is inaccurate in that it gives the average or effective power factor for the full period covered by the power bill, including transformer "reactives" at night and on Sundays and holidays when little or no power is being used. A more accurate method of determination would give the power factor at the time of the peak load, as this is really the only time the power company is vitally concerned with the consumer's power factor. However, in defense of this system of metering, it must be understood that present-day metering facilities make most other methods impracticable. Probably the kilowatt-reactive method will continue in favor for some time.

It is not possible to determine directly the power factor of a load at a particular time, if the kilowatt-hour meter and a reactive-hour meter are installed, as the readings are cumulative. However, if the ratio of the number of revolutions of the reactive meter to the kilowatt-hour meter is found by counting the speeds of the disks of the respective meters for a period of three minutes or longer, the power factor can be determined from the table. For example, if the reactive meter makes 250 revolutions in three minutes and the kilowatt-hour meter makes 200 revolutions in the same three-minute period, the ratio of 250 to 200 is 1.25, which, according to the table, indicates a power factor of 62.5 per cent.

An indicating power factor meter can be purchased at small cost by the power user and is useful in checking the power factor on various feeders to locate that part of the plant equipment which is causing the low power factor. A portable instrument is capable of still wider use, although a permanent installation ahead of all feeder switches or fuses permits checking individual circuits, provided all load except that which is to be measured is cut off the lines.

Power factor rates are now in operation in many sections of the country. In some cases a bonus is offered for high power factor; in others a penalty is imposed unless the power factor is maintained at a

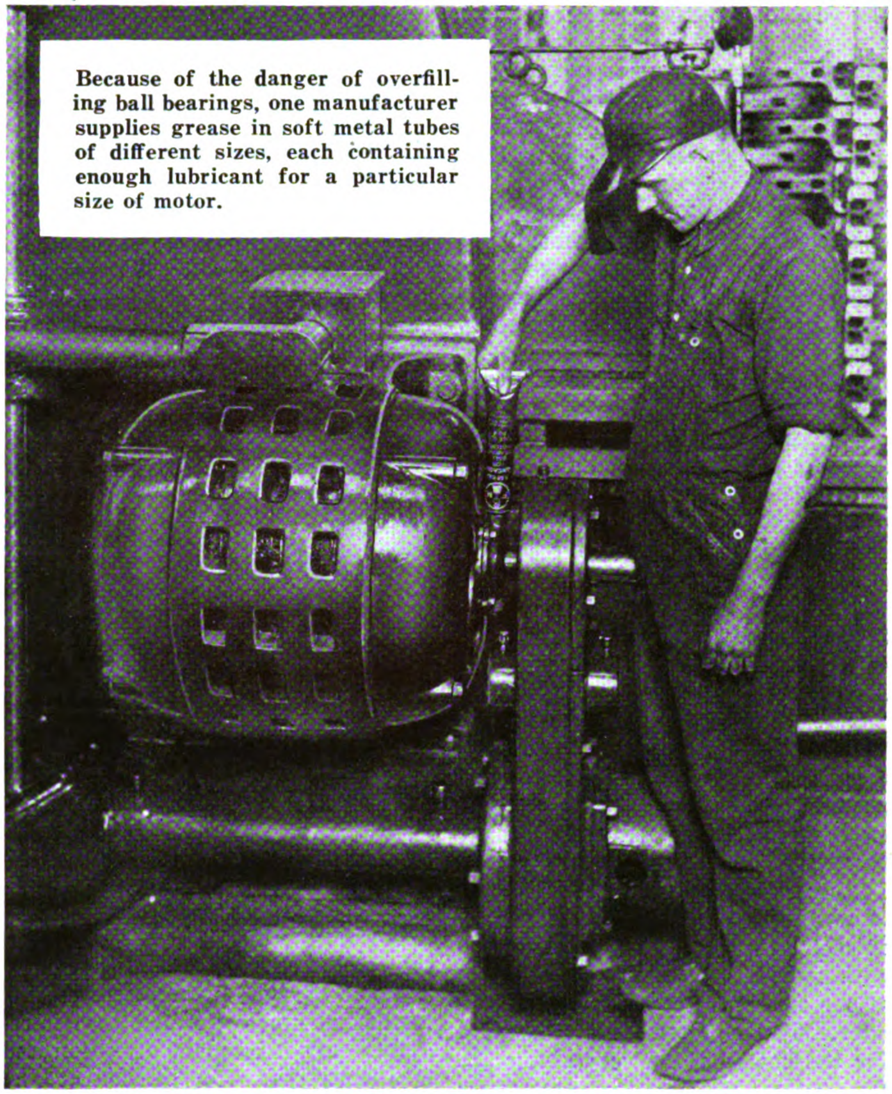
(*Please turn to page 315*)

Determination of Power Factor From Readings of Reactive and Kilowatt-Hour Meters

Ratio of React.-Hr. to Kw.-Hr.	Power Factor	Ratio of React.-Hr. to Kw.-Hr.	Power Factor	Ratio of React.-Hr. to Kw.-Hr.	Power Factor
0.00	1.00	0.76	0.795	1.35	0.595
0.10	0.995	0.78	0.79	1.37	0.59
0.14	0.99	0.79	0.785	1.39	0.585
0.18	0.985	0.80	0.78	1.40	0.58
0.20	0.98	0.82	0.775	1.42	0.575
0.23	0.975	0.83	0.77	1.44	0.57
0.25	0.97	0.84	0.765	1.46	0.565
0.27	0.965	0.86	0.76	1.48	0.56
0.29	0.96	0.87	0.755	1.50	0.555
0.31	0.955	0.88	0.75	1.52	0.55
0.33	0.95	0.90	0.745	1.54	0.545
0.35	0.945	0.91	0.74	1.56	0.54
0.36	0.94	0.92	0.735	1.58	0.535
0.38	0.935	0.94	0.73	1.60	0.53
0.40	0.93	0.95	0.725	1.62	0.525
0.41	0.925	0.96	0.72	1.64	0.52
0.43	0.92	0.98	0.715	1.66	0.515
0.44	0.915	0.99	0.71	1.69	0.51
0.46	0.91	1.01	0.705	1.71	0.505
0.47	0.905	1.02	0.70	1.73	0.50
0.48	0.90	1.03	0.695	1.76	0.495
0.50	0.895	1.05	0.69	1.78	0.49
0.51	0.89	1.06	0.685	1.80	0.485
0.53	0.885	1.078	0.68	1.83	0.48
0.54	0.88	1.09	0.675	1.85	0.475
0.55	0.875	1.11	0.67	1.88	0.47
0.57	0.87	1.12	0.665	1.90	0.465
0.58	0.865	1.14	0.66	1.93	0.46
0.59	0.86	1.15	0.655	1.96	0.455
0.61	0.855	1.17	0.65	1.98	0.45
0.62	0.85	1.18	0.645	2.01	0.445
0.63	0.845	1.20	0.64	2.04	0.44
0.65	0.84	1.22	0.635	2.07	0.435
0.66	0.835	1.23	0.63	2.10	0.43
0.67	0.83	1.25	0.625	2.13	0.425
0.69	0.825	1.27	0.62	2.16	0.42
0.70	0.82	1.28	0.615	2.19	0.415
0.71	0.815	1.30	0.61	2.23	0.41
0.72	0.81	1.32	0.605	2.26	0.405
0.74	0.805	1.33	0.60	2.29	0.40
0.75	0.80				

Example: Assume reactive meter reads 25,000 and kilowatt-hour meter 20,000 for the same month; $25,000 \div 20,000 = 1.25$. Find this figure in one of the columns headed "Ratio of React.-Hr. to Kw.-Hr." On the same line and in the next column to the right headed "Power Factor," the power factor is found to be 0.625 or 62.5 per cent.

PROPER LUBRICATION of the bearings used on power drive equipment is extremely important from the standpoint of insuring continuity of power service and reducing maintenance costs. In particular, the lubrication and care of motor bearings merit very careful consideration, inasmuch as failure or trouble with them leads to complete shutdown of the driven machines. In addition, the lubrication of motor bearings presents several problems which are not ordinarily encountered. Some of these problems and the methods of overcoming them are discussed in this article.



Because of the danger of overfilling ball bearings, one manufacturer supplies grease in soft metal tubes of different sizes, each containing enough lubricant for a particular size of motor.

Problems in

Lubricating Motor Bearings

with a discussion of some of the methods used by manufacturers of motors and bearings to reduce operating troubles

By FRANK E. GOODING
Associate Editor, Industrial Engineer

PREVIOUS articles* of this series on lubrication have discussed lubricants and the general methods of applying them. This article will treat specifically the lubrication of electric motors. It is, of course, impracticable in a restricted article of this nature to discuss each of the numerous makes of motors because in many cases the method of lubricating the bearings is quite similar in several makes. The treatment of the subject here will, therefore, be confined to a discussion of the different methods of lubricating motor bearings.

A motor has two vital parts: the windings and the bearings. Failure of either will stop the motor. It is necessary in an article of this nature to make frequent reference to bearings, in any discussion of their lubrication. Incidentally, a failure or excessive wear on a bearing often results in damage to, or destruction of, the winding also, particularly on direct-current motors. Ordinarily, however, the type of winding has no effect upon the bearings and their lubrication except that provision must be made to keep the lubricant from getting on the windings. Some of the methods of doing this will be described later in this article.

The problems involved in the lubrication of motors are important because of the dependence of continuous operation upon the driving unit. If the motor stops for any reason, the equipment driven by it also ceases to operate and in many cases, such as when one line of machines feeds to the next, other dependent machines must also be stopped. For example, in group-drive installations each machine can go or must stop in conformity with the operation of the motor. In many process industries stoppage of a motor, due to lubrication or other troubles, often may cause serious loss or damage to the product. Practically every plant has certain "key" operations which serve as the bottleneck of production; it is of vital importance that the motors driving the key machine or machines do not develop trouble or fail.

Because of this necessity of continuous operation motor manufacturers have given considerable attention to the bearings and the provisions for lubrication. These improvements, however, may be nullified by neglecting to lubricate at proper intervals, by using the wrong type of lubricant, and through the lack of sufficient protection against dust or dirt entering the bearings. Even the best bearings and lubricants are not proof against improper use, neglect, and carelessness.

The conditions under which a motor operates also affect the lubricant and, to a certain extent, the selection of the type of bearing. In

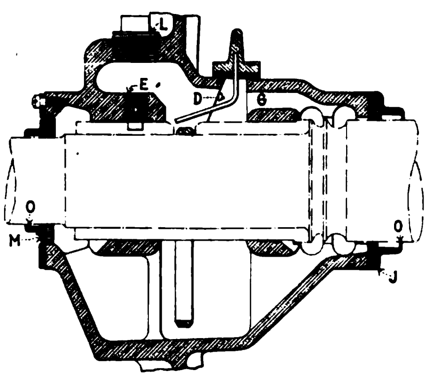
*Articles in this series on lubrication which have appeared in previous issues of INDUSTRIAL ENGINEER are: "Using Oils and Greases for Industrial Lubrication," December, 1925, "Specifications for Oil and Grease Lubricants," March, 1926, and, "Equipment Used for Applying Lubricants," May, 1926.

the case of motors operating under abnormal conditions of heat or cold, or in a dusty atmosphere, special attention must be given to the type of bearing, or the lubricant, or both.

Operation under excessively high or low temperature conditions requires special attention to the type of lubricant, as was mentioned in a previous article. Where the temperature is high, an oil must be used which will have the correct viscosity for the bearing at the higher temperatures. Manufacturers of lubricants provide special oils for use under such conditions. Also, where a motor is exposed to low temperatures a lubricant must be used which has a low "cold test" or congealing point. Similarly, where grease is used in motors exposed to heat or cold, care must be exercised to see that a grease is chosen which will have the proper consistency under the operating conditions.

One of the main problems in the lubrication of motors is to provide a means for the uninterrupted supply of lubricant to the bearings, so as to maintain the film of lubricant between the shaft and its bearing. The methods of doing this vary somewhat with the different makes of motors, but in general they fall within or are modifications of some of the types which will be explained later. These systems of lubrication for the bearings are very similar to the systems used on the same types of bearings for other industrial applications. However, where a bearing is applied to a motor it usually has some improvements or additions over other bearings of the same type when applied to ordinary industrial applications. In general, these improvements consist of better methods of retaining the lubricant in the bearings by preventing it from creeping along the shaft and thus getting onto the windings, as well as more positive means for feeding the lubricant to the bearing.

Wick Oiling—Some form of wick oiling is commonly used on fractional-horsepower motors. Wick oiling devices usually consist of a reservoir for holding the oil and the wick. The wick is generally arranged to press against the side of the shaft; in some cases it is held against the bearings by springs. The oil feeds through the wick and onto the bearings. Rotation of the shaft carries the oil away from the wick and distributes it over the bearings. Lubrication is continuous as long as the motor is in operation,

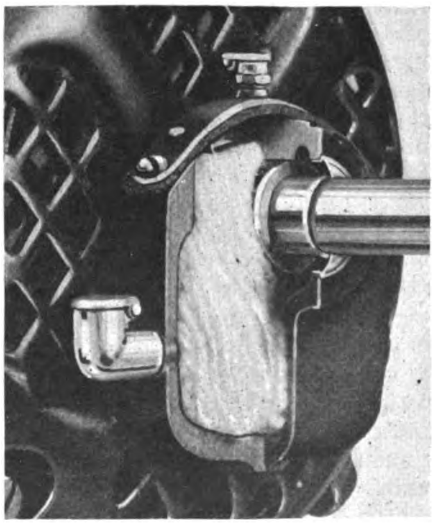


A cross-section of an improved type of ring-oiled sleeve bearing.

Special precautions are taken in this bearing to prevent oil leakage. The opening *G* is a bypass for air to prevent unbalanced air pressure within the bearing. Oil leakage from careless filling is overcome by the inner bearing cap *J*. The cover to the oil ring slot *D* is bolted down against the shellacked felt gasket. The oil ring slot *D* and oiling hole *L* are tightly closed, as shown, which in addition to the felt washer *M* seal the housing against ingress of air and thus prevent currents of air passing through the housing. The bearing cap lip *O* eliminates oil spray from ventilating air by preventing its escape at the housing along the shaft.

but the flow of oil stops when the motor is shut down. Generally the reservoir is large enough to contain sufficient lubricant to keep the wick well saturated for a long period, so that the bearings need to have lubricant added only occasionally.

Some of the advantages of this method of lubrication are that it requires only infrequent attention and is always ready for service at any time, even though the motor is operated infrequently and irregularly.



An example of a wool yarn packed bearing.

This cut-away drawing shows the position of the wool yarn as it is passed around the bearing. Oil is supplied through the spring-closing oil cup at the side. In this way, any dirt which enters the bearings while they are being oiled is not carried up to the shaft. If the bearing were oiled from the top, foreign matter might be washed down into the bearing.

Also, the wick will remain saturated for a time even though the motor, which in the fractional and small horsepower ratings is easily moved, has been upset and the oil reservoir has been drained.

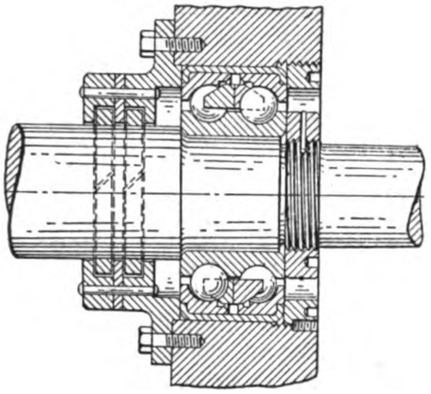
One of the most common means of preventing creeping of oil in wick-oiled bearings is to provide either a groove or opening in the bearings, or a projecting ring or disk on the shaft. As the oil creeps along the shaft it is thrown off from this disk or into the groove by the centrifugal force of rotation. Variations and improvements of this method, some of which will be shown and discussed later, are perhaps the most common means of preventing the oil from creeping along the shaft and entering the windings of the motor.

Lubrication by Packed Waste or Wool Yarn—The wool yarn method of lubrication is also frequently used on fractional-horsepower motors. This method of lubrication differs somewhat from the wick system in that the oil reservoir is usually of greater capacity, and the yarn is considerably larger than the wick. Long strands of wool yarn are used to carry the lubricant from the oil reservoir to the top of or side of the shaft by capillary action.

Bearings packed with waste instead of yarn are used on motors of larger size. Packing with waste serves much the same purpose as the yarn in the fractional-horsepower motors in that it carries a continuous supply of the lubricant to the surface of the shaft.

One of the most common applications of waste-lubricated bearings is in street railway motors. This same method is frequently used in industrial applications; however, the method of filling the bearing or oil reservoir with the waste or yarn is of considerable importance. The lubricant is carried up to the bearings along the strands of the fiber by capillary action. The waste also serves as a filter to separate out particles of dust or dirt from the lubricant and prevent them from working into the bearings.

It is necessary for the best results to have the strands of the waste or yarn run in parallel lines as nearly directly from the oil reservoir to the bearing as possible. A bearing should never be packed by merely cramming it full of waste or yarn. A better way is to fold the waste or yarn into a skein long enough to



Here two split rings are fitted to the shaft and turn in grooves in the housing.

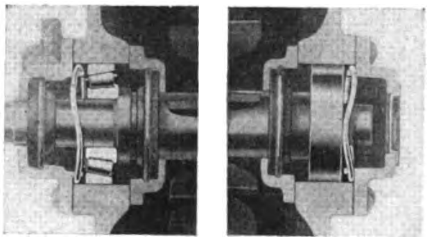
These rings form an effective oil and dust seal. Where oil is used in ball bearing motors, a more effective seal must be provided than where grease is used, because oil creeps much more easily than will grease.

reach from the top of the bearing to the bottom of the oil reservoir. It should be held in position by packing in more waste yarn.

In motors operating under high temperature conditions, which may be due either to the surrounding temperature or to heat transmitted to the shaft from the motor, the waste which comes in contact with the shaft is frequently baked or glazed. This retards the capillary flow of the oil and can be determined only by inspection, which should be frequent whenever conditions are such as described.

It is usually best to fill such bearings from the side or bottom of the reservoir, through a pipe extending out to the side, rather than to pour the oil down through the top of the bearing because of the danger of washing dust particles down through the waste or yarn and into the bearings with the oil. The top opening should be sealed and used only for inspection or repacking. Also, as with practically all other types of bearings, it is not wise to fill them too full of oil because of the additional danger of the oil creeping past any barriers and getting into the windings. With almost any type of bearing, there is seldom any excuse for filling it so that the level of the oil is high enough to touch the bottom of the shaft. This is not true, of course, of grease-lubricated ball bearings.

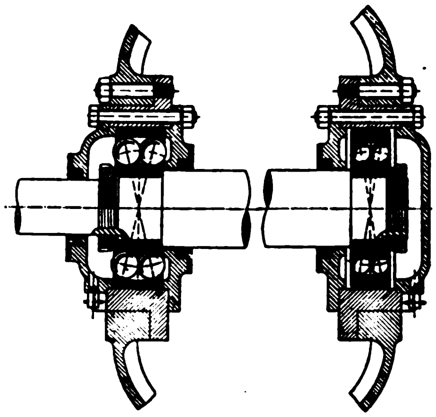
It is also well to provide an oil gage or some means of indicating the depth of oil in the reservoir both for inspection and to indicate the oil level to the oiler. Care must be exercised to see that this gage line does not fill up. Ordinarily the gage



The tapered roller bearings in this motor are arranged for grease lubrication. The bearings are sealed to retain the lubricant and keep out foreign matter.

is on the same line as is used to fill the bearing.

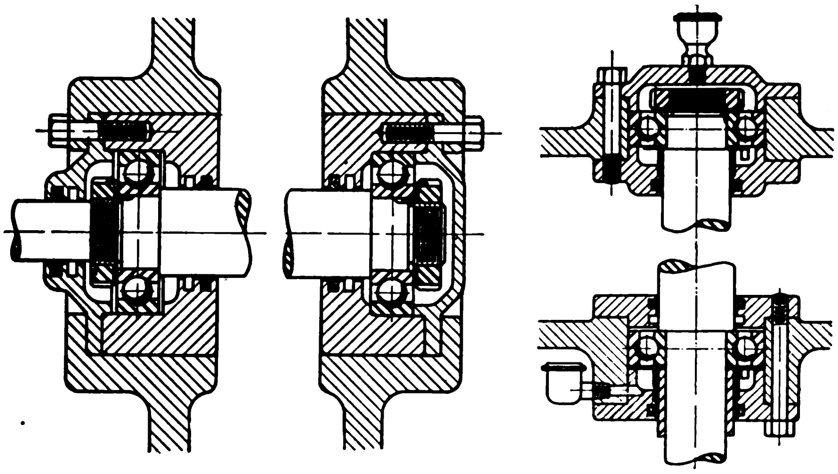
Ring Oiling—One of the best known methods of lubricating motors is by means of a ring oiler. Briefly, the elements of a ring-oiling bearing consist of a bearing, shaft, an oil reservoir, a loose ring, and provision for preventing oil creep. The ring fits on the shaft and dips down into the oil reservoir; the rotation of the shaft turns the ring which carries oil up from the reservoir and deposits it on the shaft. Some of the advantages of this type of bearing are that it is simple, lubrication is positive, and there is little chance for anything to get out of order.



Another method of installing ball bearings for grease lubrication on a motor.

In this case the housing seals or shaft enclosures are of the felt washer type, which will effectively prevent leakage of the grease provided a suitable lubricant is selected. The grease should have a higher melting point than the highest temperature attained by the bearing in operation. This may be 10 deg. to 50 deg. F. in excess of the temperature of the adjacent parts of the motor, which of course are subject to electrical heating. These bearings have Alemite fittings but the housing should never be filled more than one-third to one-half full of lubricant.

With some of the old type bearings difficulties resulted from the ring sticking to the side of the groove in which it fits, or jumping out of its groove; in most modern motor bearings these difficulties have been overcome. Where ring-oiling bearings have given trouble from excess oil on windings, it has often been traced to the practice of filling the bearing too full of oil, which does not permit the functioning of the "oil thrower," or other means of preventing "creep." Where



Methods of mounting and lubricating ball bearings on horizontal and vertical motors.

The pair of illustrations at the left show the type of mounting which is known as the "cartridge closure" for horizontal motors with solid end bells. The cartridge mounting differs from the standard mounting in that the bearing is not mounted in the end bell but in a separate housing that fits into the end bell as a unit so that the end bell can be taken off and the windings exposed for inspection without exposing the bearing. This arrangement, it is stated, not only simplifies the construction, but also helps to exclude dirt from the bearings in that they do not have to be opened when inspecting the windings. The seal, which is for grease lubrication, consists of a groove and felt packing. The pair of bearings at the right show a method of oil lubrication on a vertical motor. A special sleeve and packing are used to retain the lubricant.

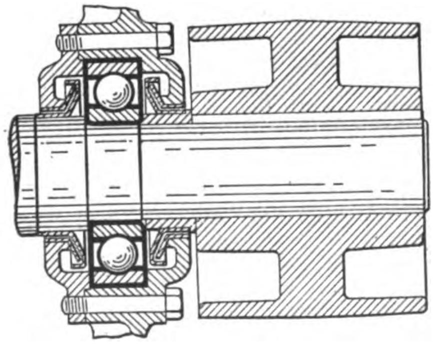
the oil is high enough to touch the shaft it is almost impossible to make a seal tight enough to retain the oil. With the reservoir too full the feed of the oil to the bearings keeps so much oil on them that the excess does not have an opportunity to flow back directly into the reservoir.

Another difficulty with ring-oiled bearings is often due to inadequate reservoir capacity. The reservoir serves three purposes, namely; for storage, as a settling chamber, and to permit the oil to cool by radiating the heat. Where the reservoir is too small, the ring keeps the oil agitated and does not give impurities an opportunity to settle. This difficulty can sometimes be remedied by inserting a short length of pipe with a cap on the end into the drain opening. This increases the capacity of the reservoir and also provides the length of pipe as a settling and cooling chamber.

Another method of preventing oil creepage, in addition to the disk or oil thrower and grooves, is by means of felt or composition wiping rings. These also serve to prevent the entrance of dust.

The rate of flow of the oil through the bearing to the reservoir is controlled largely by the grooves in the bearings and the viscosity of the oil. If an oil has too high viscosity and flows too slowly through the bearing grooves it may cause trouble. This may be remedied by selecting a lubricant of lower viscosity. However, if the bearing is to operate under conditions of high temperature, it is well to use an oil of somewhat higher viscosity than for ordinary conditions, because the effect of the heat is to thin the oil and decrease its viscosity.

Within the past few years motor manufacturers have directed considerable effort toward the improvement of sleeve bearings and the ring oiler. Many such bearings, which are very reliable even under adverse conditions, are now available.



In this case the oil slingers are made of thin sheet metal.

One slinger revolves with the shaft and the other is fixed to the housing. The clearance between the two is very small.

Specifications of Grease for Ball Bearings

The essential characteristics of a suitable grease for use on ball bearing motors, as given by one manufacturer, are as follows:

(1) Consistency should be a little heavier than that of vaseline. About Nos. 2 or 3 as graded by automobile grease manufacturers. A grease of this consistency is stiff enough not to churn at high speeds, yet soft enough to protect the balls and races.

(2) Melting point should be as high as possible—180 deg. F or higher.

(3) Grease should have no tendency to gum or harden.

(4) Grease should not contain abrasive or body-giving matter, such as talc, graphite, or ground pumice.

(5) It should be made on a mineral base—not vegetable or animal.

(6) Free acid or alkali should not run over 0.1 per cent.

(7) Consistency of the grease should not change at lowest outside and maximum motor temperatures.

(8) There should be no tendency to separate while standing.

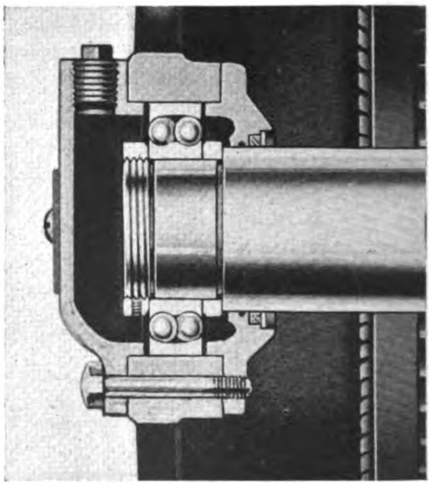
Ball and Roller Bearing Lubrication—During the past few years, manufacturers of electric motors have been giving increasing attention to the demands of motor users for bearings which will stand up under severe operating service over a long period of time, even though it might be difficult to get at them for regular and frequent oiling. This was particularly true of motors operating under severe conditions and where they are difficult of access. The solution of such operating problems has been met very extensively through the use of ball and roller bearing motors.

The recommendations of manufacturers of ball and roller bearings vary somewhat as to the type of lubricant to use. In some cases grease is preferred, while in others oils are used. Among the advantages which have been found to result from the use of ball or roller bearings in motors, one which stands out perhaps more than the others is the reduction of labor in oiling. With ordinary bearings, and under some operating conditions, motors require the attention of the oiler at least once a day or oftener; in other cases, a longer period may intervene, but it is advisable at least to give the motors frequent inspections to see that the oiling system is working properly.

Except under very unusual conditions it is ordinarily sufficient to oil or grease ball or roller bearings on a motor only about once or twice, or at the most three or four times, a year. Many companies make a practice of adding lubricant at half-year periods and cleaning out the bearings and refilling at the end of the year. This requires only a fraction of the attention and labor necessary where a bearing must receive attention each day. Also, the consumption of lubricants is much less.

The function of the lubricant in a ball or roller bearing is somewhat different from that in other types of bearings in that one of the important purposes is to protect the metal in the balls or rollers from corrosion. For this same reason lubricants should be free from acid or alkali. The metal has a high finish and if it were left exposed would corrode or pit which would be very detrimental to the operation of the bearing. Also, because of the rolling action of the metallic surfaces, instead of sliding friction, as in other bearings, practically no heat is generated and so the lubricant does not have to cool the bearing. In this way a smaller quantity of lubricant is required than in other types of bearings. Consequently, the bearing cavities may be smaller.

Many manufacturers caution users against filling a ball or roller



This ball bearing motor is designed for grease lubrication.

The bearing is sealed against dust and escape of lubricant by the packing ring and groove, as may be seen in the illustration.

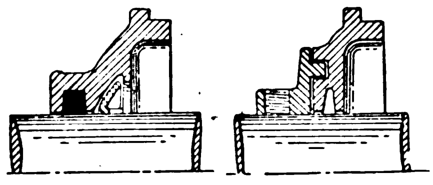
bearing too full of lubricant, and particularly against filling it under pressure. In case such bearings are filled too full of lubricant or under pressure, the churning of the lubricant by the balls or rollers heats up the bearings. Also, if a bearing is filled under pressure there is a tendency for the lubricant to work out of the bearing past any barriers which the manufacturer has placed along the shaft and which will prevent creepage under ordinary conditions. Where a bearing is filled with a grease of too heavy consistency or oil of too high viscosity, there is also a tendency to heat because of the friction of the oil or grease.

As stated before, some manufacturers recommend grease as a lubricant. One of the advantages is that grease is considered less likely than oil to creep along the shaft. Also, it is easier to provide a seal when grease is used. A grease that is so thin that it will flow freely will, it is stated, churn and heat up at speeds around 5,000 r.p.m. One manufacturer, however, recommends greases, of properly selected consistency, for use at speeds up to 7,500 r.p.m. Specifications for a grease for ball bearing motors, as given by one manufacturer, are shown in the accompanying table.

Cleaning—The design of the bearing, the adequacy of the seal, and the service conditions determine the frequency of attention. Ordinarily ring-oiled bearings should be cleaned at much shorter periods than ball or roller bearings. Ring-oiled bearings, however, can operate with contaminated oil better than can ball or roller bearings.

When cleaning, any gummed oil or grease as well as accumulated dirt and grit, should be removed. One method of cleaning the bearing housing is to remove the top and bottom plugs from the housing and drain out the lubricant. Next, replace the bottom plug and fill with kerosene, gasoline, or a light lubricating oil heated to about 200 deg. F. until the oil appears at the oil filling opening. The top plug should then be replaced and the motor turned over by hand a few times to distribute the solvent. In about 10 min. the plugs can be removed and the housing drained; rotate the motor slowly by hand while draining. The bottom plug should then be replaced and about ½ pt. of clean oil poured into the housing; a few turns of the motor by hand will distribute the clean oil and wash out any kerosene or other solvent which might affect the fresh oil. This flushing bath is then drained and the bearing filled to the proper level.

For ordinary motor service, renewing the grease in ball or roller bearings once a year is ample. Under any conditions the most frequent renewal is every three months. At the time of renewal the packing rings should be inspected, if these are used. This is also a good time to note the quality of the grease last used, and to see whether or not it has hardened. The tendency of grease to cake is really what determines the frequency of lubrication and cleaning. In renewing grease care must be taken not to let dirt get into the housing.



Two other types of seals for oil-lubricated ball bearings.

The illustration at the left shows a combination oil slinger and a dust-proof felt washer, which is indicated in solid black. The seal only is shown in both of these illustrations. The illustration at the right shows a combination labyrinth groove to exclude dust and an oil groove which drains back into the bearing housing.

Closure—Each motor manufacturer has methods of his own to close the bearing against leakage, and also against the entrance of foreign material. A few of these methods are shown in some of the accompanying illustrations. The discussion of each closure is given in the caption accompanying the illustration. It may be said, however, that in general the purpose of the end bell of a ball or roller bearing motor is to perform three functions: (1) To hold the outer ring of the bearing and do this in such a way as to make assembly and disassembly easy. (2) To retain lubricants. (3) To exclude foreign matter. Some of the means of doing this may be seen from a study of the illustrations.

It is easily seen, therefore, that the selection of the proper type of lubricant is of great importance. The manufacturer's recommendation can be taken in any case where a motor is operating under any ordinary conditions. If abnormal service conditions are involved, it is well to consult with either the manufacturer of the motor or the bearings, or both.

Low Power Factor Causes Trouble

(*Continued from page 310*)

certain point. Some rates adjust only the demand charge for power factor; others charge only the energy rate, while a few adjust both demand and energy charges in accordance with a fixed schedule.

One of the simplest rates now in operation specifies that for each 1 per cent by which the power factor is maintained above 90 per cent, a discount of 1 per cent will be allowed on the demand charge; whereas, for each 1 per cent by which the power factor is below 80 per cent, a penalty of 1 per cent will be imposed. This rate has been used satisfactorily for over a year on the lines of an operating company in Northern Indiana.

Another rate which has been quite popular does not include a penalty clause, but specifies a discount of 5 per cent if the power factor is maintained over 80 per cent, and a discount of 10 per cent if it is kept at 90 per cent or better. The Rockford, Ill., Electric Company uses this rate.

Probably the most widely used power factor rate is based upon an average or effective power factor of 85 per cent. It operates as follows:

Average Power Factor	Multiply Kw.-Hr. by This Constant
1.00	.951
.95	.965
.90	.981
.85	1.000
.80	1.023
.75	1.050
.70	1.0835
.65	1.1255
.60	1.1785
.55	1.2455
.50	1.3335

An examination of this rate will disclose the fact that low power factor results in greatly increased bill, while high power factor gives a substantial reduction. This rate is used by the American Gas and Electric Company properties in Indiana, Michigan, Ohio and elsewhere.

Another widely used rate is based upon the following equation:

Net billing = (regular billing $\times$ .85) $\div$ average power factor.

At 50 per cent power factor a penalty of 70 per cent is imposed, while at 100 per cent power factor, a bonus of 15 per cent is earned.

Methods of raising the power factor of an industrial plant will be discussed in other articles which will appear in succeeding issues.

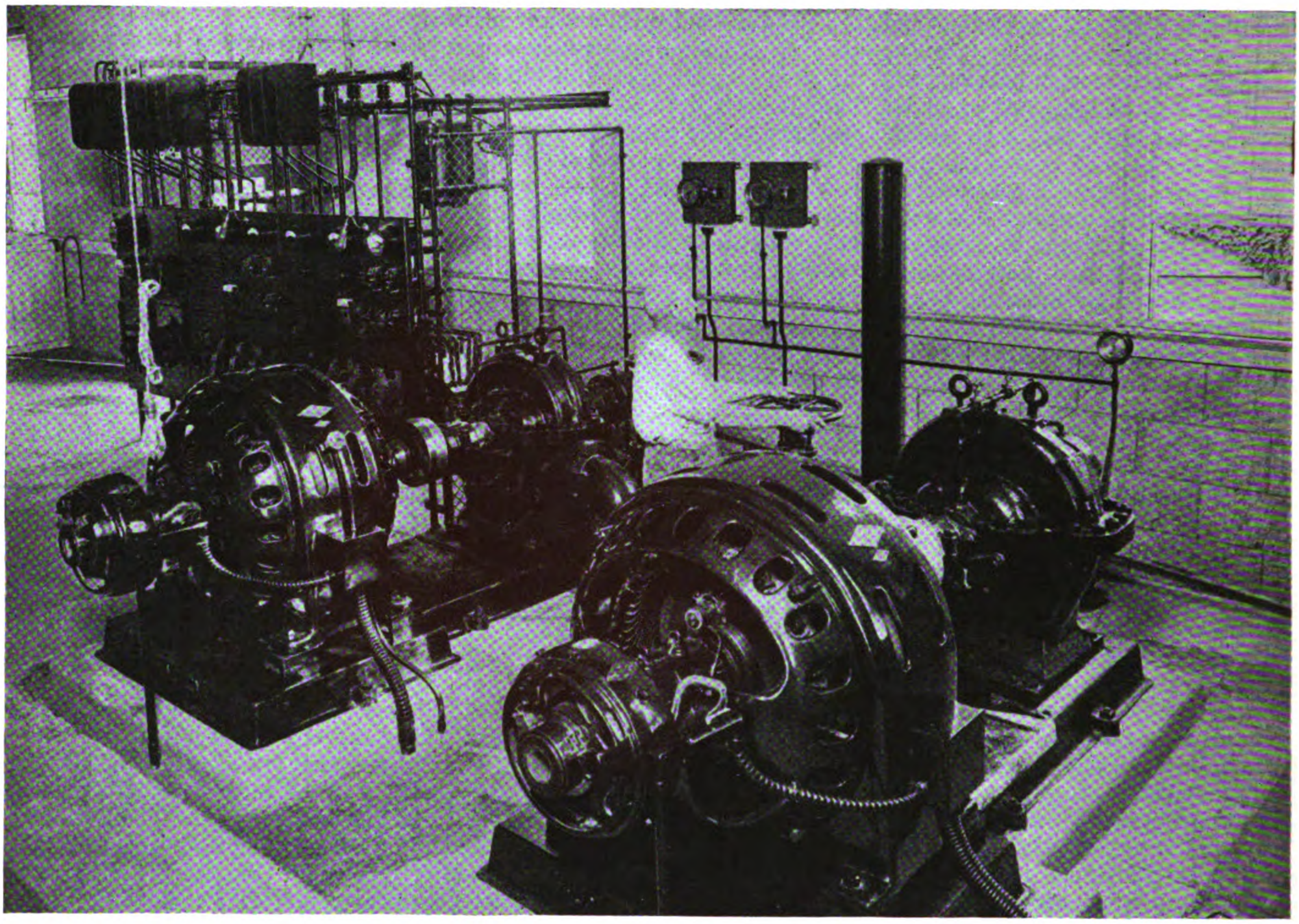


Fig. 1—The synchronous motor is particularly adapted for driving constant-speed centrifugal pumps.

These two 200-hp., 1,500-r.p.m., 2,200-volt Electric Machinery Co. synchronous motors are driving Worthington single-stage centrifugal pumps. Exciters of 2-kw. capacity are direct-connected to the motor shaft. The control for the motors may be seen in the left background.

Power Drive Equipment for Industrial Pumps

together with a discussion of their operating characteristics which affect the selection of the motor, control, and drive connection

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THE preceding article on the application of motors to pumps, published in the May issue, gave the details of the operating characteristics of reciprocating, rotary, and centrifugal pumps and discussed briefly the application of motors to them. This article will go more into detail regarding the selection of motors, control, and drive equipment for the different types of pumps.

In the majority of pump drives approximately constant quantities and heads are involved. If this is not the case the best method of meeting the range of requirements should be carefully considered.

With a reciprocating or rotary pump the quantity of liquid delivered is closely proportional to the speed and almost independent of the head. Reduction in quantity can be obtained either by a reduction in speed or by an overflow provision, the latter being relatively wasteful. A reciprocating pump working against a given head requires constant torque at any speed, and the horsepower is in proportion to the speed at which the pump is operated.

In the case of the centrifugal pump, delivery can be reduced by reducing the speed or by throttling, which increases the head against the pump and thereby decreases the quantity. Let us consider the effect of change of speed on a centrifugal pump.

A change in pump speed causes a change in the head developed by the pump and also a change in volume.

Fig. 2 shows the characteristics of a pump at normal speed and at speeds above and below normal over a limited range. A series of efficiency curves are included which indicate at their intersections with the head-capacity curves, the conditions which give 100 per cent, 95 per cent, etc., of maximum pump efficiency. Let us assume that the maximum efficiency of this pump is 70 per cent. The pump has this efficiency at 100 per cent rated speed and 100 per cent rated capacity, also at 110 per cent speed and 110 per cent capacity, etc. At 110 per cent speed and 75 per cent

capacity, the pump has an efficiency of 92 per cent of 70 per cent, or 64.3 per cent.

It should be noted that the pump manufacturers' characteristic curves are based on a fixed speed. These curves are somewhat modified by the speed regulation of the motor, tending to give increased droop to the capacity-head curve. This effect should be borne in mind particularly when compound-wound motors or variable-speed, wound-rotor motors with secondary resistance are used. In exceptional cases it may be desirable to modify the pump characteristics by this means.

When the speed of a pump is increased, the point of maximum efficiency occurs at a higher head and greater volume than at normal speed. When the speed of a pump is reduced below normal speed the point of maximum efficiency occurs at a lower head and lesser volume than at normal speed. This can be seen from inspection of Fig. 2.

If a centrifugal pump is operated against a constant head and if the speed be changed to vary the output, the pump efficiency will change materially, due to the different portions of the characteristic curves on which the pump will be worked. Fig. 3 is of interest in this connection. In it are shown how the volume, head, efficiency, and power vary with changes in speed in the case of the pump whose characteristics are shown in Fig. 2. It is assumed that this pump operates against a fixed static head of 80 per cent of rated head. The balance of the system head is friction head; thus at rated delivery, the friction head is 20 per cent of rated head.

Due to the presence of the static head the effect of speed changes can be determined only by study of the characteristic curves at the different speeds. It will be seen from Fig. 3 that this pump will deliver little or no volume until it exceeds 80 per cent speed; thereafter the volume increases faster than in direct proportion to the speed. The total head increases approximately directly as the speed, and not as the square of the speed. The speed-head curve in this case happens to be an approximately straight line. The efficiency is less at speeds above and below rating because the system characteristic is such that the pump operates slightly off-rating at speeds above and below normal speed. At considerably reduced speeds, when the developed head approaches the static head and the volume decreases, the efficiency falls very rapidly. The horsepower increases from shut-off value at about 80 per cent speed at a rate faster than the cube of the speed. It is also evident from this study that the speed of a pump cannot be reduced greatly below rated speed if the rated head is largely static head.

As explained in the fourth paragraph of this article, the delivery of a centrifugal pump can be reduced by reducing the pump speed or by throttling the discharge. The effect of changing the pump speed has just been considered. Let us now discuss the effect of throttling.

If a centrifugal pump has a flat capacity-head curve a small increase in system head, obtained by throttling, will cause a relatively great decrease in delivery. The loss of power incident to the false head is then moderate. If a pump has a steep capacity-head curve it is necessary to increase greatly the system head by throttling in order to reduce the discharge. The loss due to this false head then becomes a material factor.

A comparison of relative efficiencies of control of delivery by throttling as compared with variation of motor and pump speed, using armature or rotor resistance, must weigh the fact that with varied speed, the combined efficiency of motor and control falls off with reduced load and increased slip, while the water horsepower or pump load rapidly decreases. With throttled discharge the drive efficiency is well maintained, but the pump load decreases only slightly, to an extent dependent upon the pump characteristics.

The feasibility of throttling the discharge for volume control depends to a large extent upon the system characteristic. If the system head is largely static head a reduction in volume is not attended by a great decrease in normal friction head. If the system head is largely or entirely friction head a reduction in volume is normally attended by a material reduction in friction head. In this event the false head must offset this normal decrease in friction head and must introduce

Figs. 2 and 3—How change in speed affects the output of a centrifugal pump.

Fig. 2 shows the characteristics of a pump when operating at normal speed, at 10 per cent below rated speed and at 10 per cent above rated speed. In Fig. 3 is shown how the characteristics of this same pump vary with change in speed. In this graph, volume, horsepower, efficiency and total head are plotted directly against change in speed.

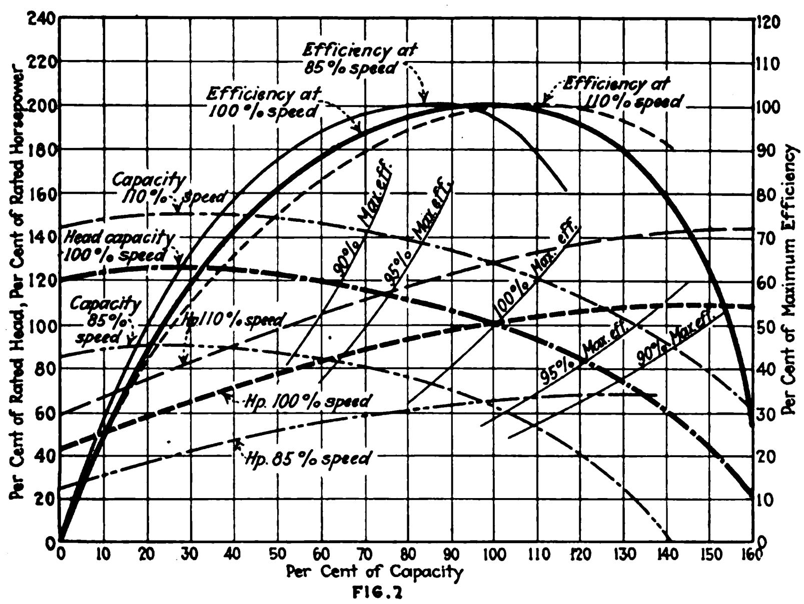


FIG. 2

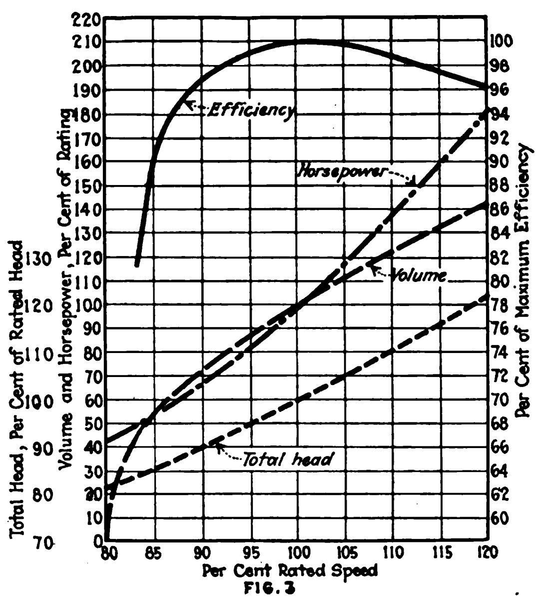


FIG. 3

sufficient additional false head to bring about the desired reduction in volume. The normal decrease in water horsepower due to reduced pipe friction at reduced volumes is thus absorbed in throttling with a material loss in economy. Where the system head is largely static head the losses due to throttling are less pronounced.

Small centrifugal pumps are more commonly operated at constant speed, the delivery being controlled by throttling. For the larger pumps, particularly if they are to be operated for long periods at reduced delivery, it is advisable to calculate the electric power consumption with the different methods and to determine whether the saving, if any, using adjustable-speed drive, will justify the greater investment incident to this type of drive. In this connection it may be well to call attention to the considerable power loss which may arise through the not uncommon practice of installing oversize pumps and throttling the discharge. A few feet of false head will more than offset any possible savings in electrical energy.

Application of Motors to Variable-Speed Pumps

Where speed adjustment of pumps is desired, the wound-rotor induction motor is most commonly used. As the load is ordinarily of a non-fluctuating character and as the speed range desired is usually small, this method is quite satisfactory as to performance. The loss in the secondary resistors is an item, but it is ordinarily not serious where only a small speed range is involved.

In laying out the resistance for speed control of wound-rotor motors used on pumps, it is necessary to consider the torque requirements of the pumps at different speeds. The torque required by a centrifugal pump falls off at a rate between the square and the cube of the speed reduction, depending in part on the system characteristic. The torque of a reciprocating pump or a rotary pump depends directly upon the system head. If the head is largely static, the torque is nearly constant. The loads and the losses at reduced speeds are then relatively great. If the head is largely frictional, the torque falls off approximately as the square of the speed reduction. The loads and the losses at reduced speeds are then relatively small.

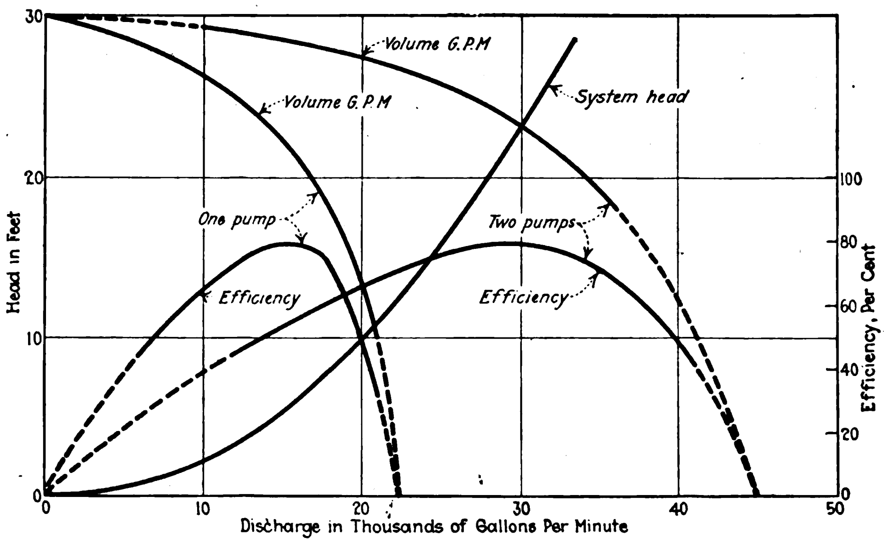


Fig. 4—Two duplicate pumps operated in parallel will not commonly deliver twice the quantity delivered by one pump.

This is due to the fact that the increase in system head incident to the greater quantity of liquid pumped may cause the combination of pumps to operate higher on the system head curve. From the volume curve it may be seen that one pump operating on the required system head, as shown by the intersection of the volume and system head curves, will deliver 21,000 g.p.m. at an efficiency of 40 per cent, while two pumps will deliver only 30,000 g.p.m., but at an efficiency of 80 per cent. Although the addition of a second pump increases the quantity pumped by only 43 per cent, yet the efficiency of operation is doubled by using two pumps; hence the use of two pumps is more economical in this case. The opposite condition is shown in Fig. 7.

The torque relations outlined above must be considered in proportioning the secondary resistance for speed control of a wound-rotor induction motor in pumping service. It is customary to supply resistors proportioned for constant torque for use with reciprocating pumps and proportioned for "fan duty" for use with centrifugal pumps, unless otherwise specified. It will be seen that in some cases such design is not entirely correct.

The brush-shifting commutator motor is well adapted in its characteristics for driving centrifugal pumps where speed adjustment is desirable. The principal deterrents to the use of this type of motor are its higher first cost and somewhat greater complication. In any specific case the economy of this type of drive, as compared with the wound-rotor induction motor with secondary resistance, should be evaluated for justification of the higher first cost. Ordinarily this type of motor can be justified only if the pump is to operate at reduced speed continuously for long periods.

The multi-speed induction motor has been successfully applied in several instances where two fixed speeds will suffice, notably for surface condenser circulating pumps. The lower speed usually will be about 75 per cent of the higher speed. The horsepower required at the lower speed is materially less than at the higher speed, the exact relation depending upon the system and pump characteristics.

It is sometimes feasible to supply two motors of different speeds, each motor being large enough to drive the pump at its respective speed. This method involves a high first cost but there may be a material power saving as compared with the use of a wound-rotor induction motor. Also the power factor, when using this method, at the lower speed, will be better than that of the multi-speed motor. This type of drive can be justified in case of long periods of operation at a reduced speed.

Using Two Pumps to Supply Variation in Demand

Not infrequently variation in water requirement is met by the use of two or more pumps, the number of pumps in service being suited to the demand. In this connection it should be noted that on a given system, two duplicate pumps will not commonly deliver twice the quantity delivered by one pump. This is due to the fact that an increase in system head incident to the greater quantity may cause the pumps when in combination to operate higher up on the head curve and at lesser deliveries than when running alone. The efficiency of the pumps is also affected by the different point of operation. These relations are brought

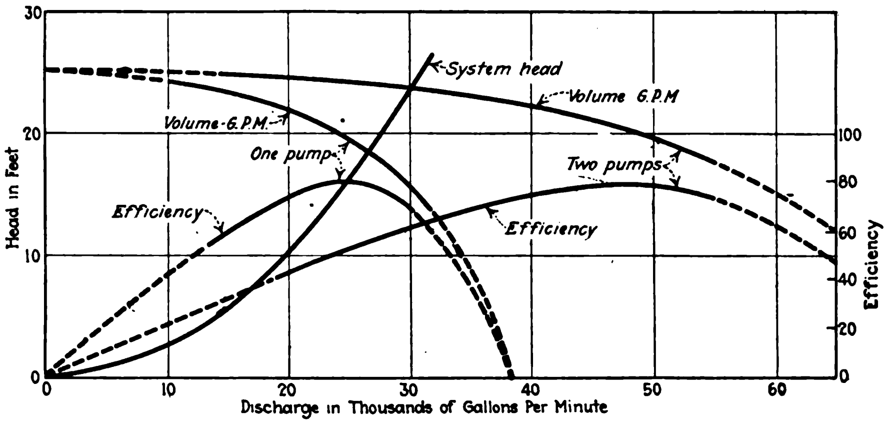


Fig. 7—Pump efficiency must always be investigated when using two identical, constant-speed centrifugal pumps.

This graph shows the characteristics of two pumps differing from those shown in Fig. 4, but operating on the same system. The intersection of the system head curve and the volume curve for one pump gives a volume or capacity of 27,000 g.p.m. at a pump efficiency of 80 per cent. Two pumps operating in parallel deliver only 11 per cent more or 30,000 g.p.m. and both pumps operate at 60 per cent efficiency. Hence it is much more economical to operate the pumps singly.

out clearly in Figs. 4 and 7. Fig. 4 shows two duplicate pumps driven at constant speed. The application is such that the best pump efficiency is obtained when the two pumps operate in parallel. Fig. 7 shows two duplicate pumps differing from those shown in Fig. 2 but operating on the same system. In this case the best efficiency is obtained when the pumps operate singly. The proper pump selection in such a case depends upon whether single or parallel operation prevails.

In Figs. 4 and 7 the system head is entirely frictional. Where static head is more predominant and the system head curve is flatter, the differences between single and parallel performance are less marked.

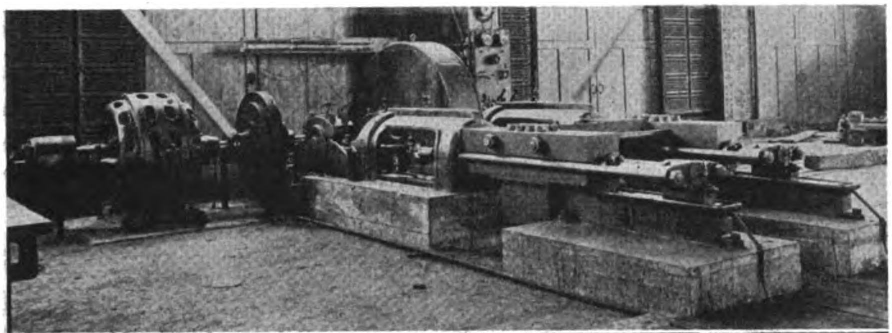
Where direct current is available the adjustable-speed motor may be employed to provide speed control. Armature resistance control instead of shunt field control of speed may also be used, thus paralleling the performance of the wound-rotor induction motor. The higher efficiency of the adjustable-speed type motor ordinarily warrants its selection in case of extended operation at reduced speed. It is permissible that an adjustable-speed motor for pump drive have a higher horsepower rating at high speed than at low speed.

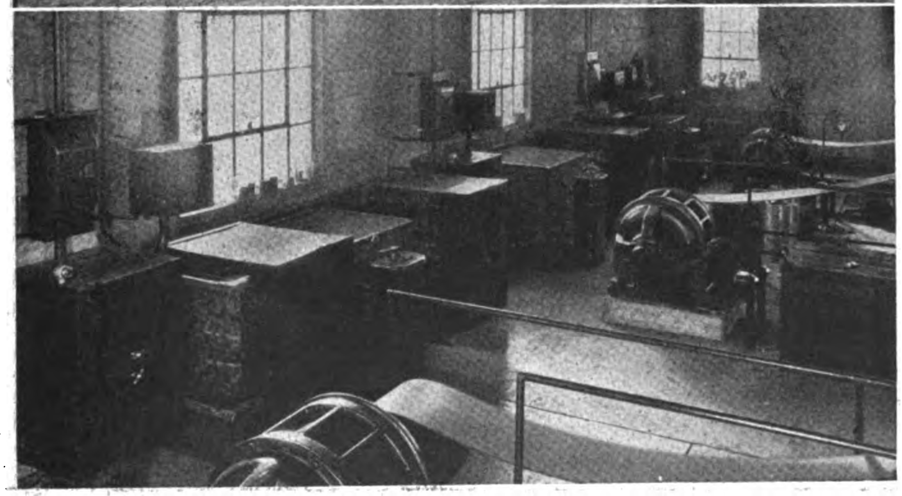
Where alternating current only is available it is seldom feasible to convert to direct current in order to utilize the adjustable-speed, direct-current motor for a pump drive. The conversion loss offsets any possible power saving, giving little justification for the investment involved. Where both alternating and direct current are available the relative costs of the two services must be considered in making a selection.

Where a standpipe or other sufficient storage provision exists, the delivery of a given constant-speed pump may be varied by operating the pump intermittently, automatic control being provided, this in turn being governed by a float or pressure switch. This arrangement necessitates starting the pump under load. It also requires a storage sufficient, with respect to pump capacity and service demand, so that periods of pumping and rest will not be of too brief duration.

If a centrifugal pump delivers to a system upon which a standpipe floats, the delivery of the pump will automatically vary as the level in the standpipe changes, due to the drooping capacity-head curve of the pump. This automatic adjustment of output, with pumps driven at constant speed, may suffice to meet the variation in demand.

A centrifugal pump delivers a greater quantity at heads below rating. In so doing it requires more than normal driving power. Different pumps vary in degree. Pumps having a steep capacity-head curve will not vary delivery much, except with marked change of head. Pumps with a flat capacity-head curve may deliver widely different volumes, with slight changes in head. Their power demand varies accordingly. Many modern pumps are so designed that the load can exceed rated load





Figs. 5 and 6—Pump drives having heavy starting torque require special provisions for starting.

In Fig. 5, upper view, the 350-hp., 500-r.p.m., synchronous motor is connected to a high-pressure, duplex, reciprocating pump by means of a Cutler-Hammer magnetic clutch. Fig. 6, below, shows three 75-hp., 440-volt, wound-rotor motors driving triplex pumps used for railway water supply purposes. The wound-rotor motors supply a large starting torque and also give variable speed when desired. The motors are controlled by means of Industrial Controller Company automatic secondary-resistance controllers.

relatively little even with free discharge. A pump of this type is "non-overloading" only if it is selected and motored on the basis of its normal rating. If it is selected and motored on the basis of a lower capacity operating point a material overload may be possible.

In selecting a motor to drive a centrifugal pump the size should be based on the power requirement at the minimum head and maximum delivery probable, as the load is then usually greater than with rated conditions. A motor for a "non-overloading" pump should correspond in rating with the maximum load the pump can develop.

The writer recalls a case in which two motor-driven centrifugal pumps operating in parallel delivered to a system having a standpipe. One motor tripped off due to a fault. The other motor and pump operating alone could not maintain the level in the standpipe. As the level fell, the load on the second motor increased until the overload protection tripped this motor and shut down the system entirely. Such conditions must be forecast and provided against.

The load of a centrifugal pump varies rapidly with change in speed. For this reason any condition which may cause a speed increase may lead to overloading the motor. Such conditions might arise through high frequency or, with direct current, through variable voltage or through motor speed above rating. Pumps are commonly designed for full-load, induction-motor speeds. If a synchronous motor is used the fact that it will maintain synchronous speed should be considered.

Not infrequently it is essential that there be no interruption in the operation of pumps where continuity of water supply is of vital importance. Electric drive is sometimes viewed with askance in such cases. If sole dependence is placed on motors every precaution should be taken to protect the source of power and to prevent motor and control faults. In such cases oversize motors may be warranted to enable pumps to "hang on" during periods of low voltage. An induction motor will develop approximately one-quarter of its pull-out torque at half voltage. The usual motor, having a pull-out torque of 250 to 300 per cent, will develop full-load torque down to about 60 per cent voltage. Where under-voltage release or protection is included in the control a time-delay feature may be desirable to avoid shutting down the pump in the event of momentary voltage drop. Not infrequently the under-voltage protection is omitted altogether. Likewise it is not uncommon practice to omit overload protection in favor of differential protection to prevent shutdowns for causes other than faults in the motor, or leads.

Figs. 8 and 9—Remote-control, high-voltage starters for squirrel-cage and wound-rotor motors.

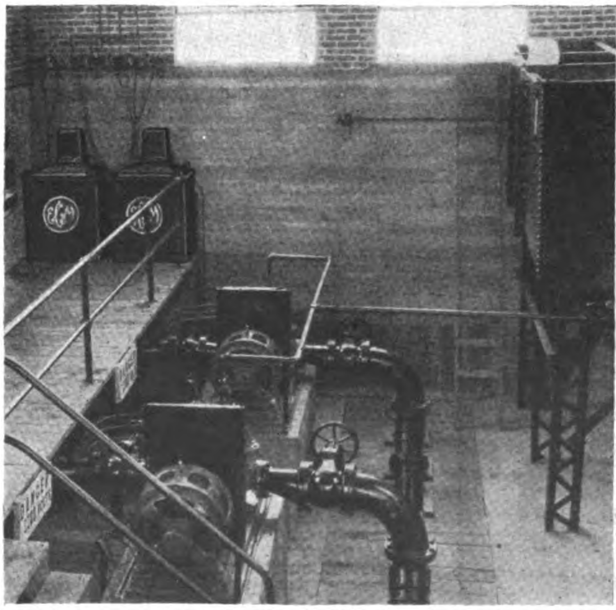
Fig. 8, left, shows an installation of Electric Controller & Mfg. Co. high-voltage compensators controlling two 30-hp., 2,200-volt squirrel-cage motors driving centrifugal pumps used for fire service at the plant of the Ohio Seamless Tube Co., Shelby, O. Fig. 9, right, shows the complete control for two Allis-Chalmers wound-rotor motors driving centrifugal pumps furnishing the water supply for a large steel mill. The motors are rated at 700 hp., 6,600 volts, three phase, 60 cycles and are controlled by Cutler-Hammer remote-control panels.

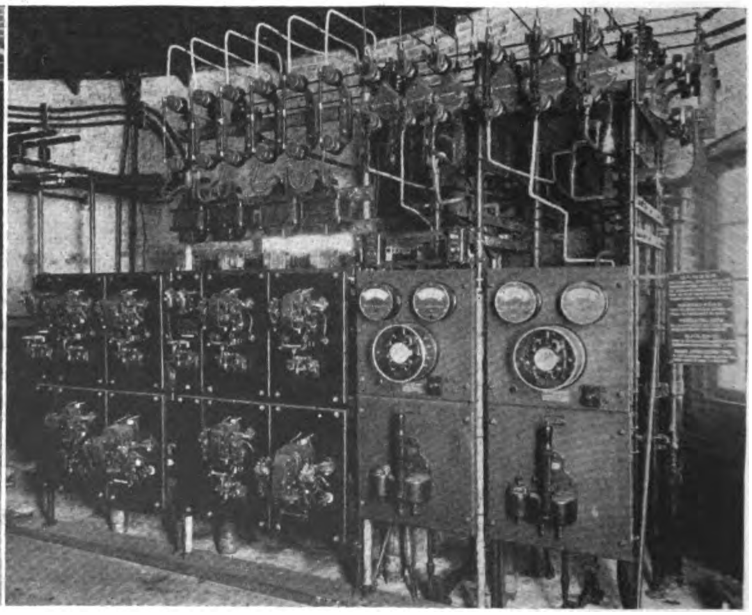
Where undervoltage protection is omitted the motor and control should be adapted for automatic restarting. Squirrel-cage motors with double cage winding for full-voltage starting are particularly suited for this function. Other types of motors can be readily arranged for automatic restarting, particularly if they are equipped with full magnetic control. Automatic restarting is considered highly desirable in some cases.

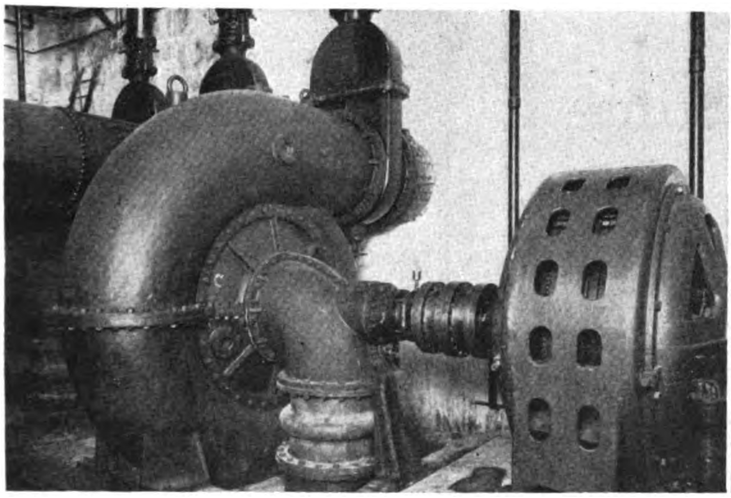
Starting Requirements of Each Type of Pump

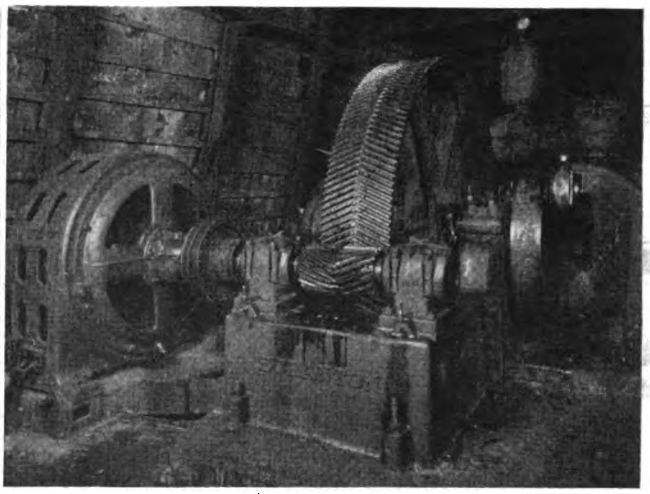
A reciprocating pump, in starting from rest while connected to the system, creates a severe starting condition. Due to the sliding pistons or plungers and tight stuffing boxes the static friction of the reciprocating pump is high. In addition, the positive displacement characteristic requires the development of full pumping torque throughout the acceleration period. If a flywheel is used this adds to the starting requirements. The initial torque of a reciprocating pump may be 125 per cent to 250 per cent of full-load torque. Fig. 5 shows an application of a magnetic clutch so as to permit the use of a synchronous motor on a reciprocating pump drive.

The rotary pump differs materially from the reciprocating pump in starting characteristics. Due to the absence of tight-fitting parts the static friction is less and the "break-away" torque is lower, being on the order of 30 to 60 per cent of normal full-load torque. As the full pumping torque is immediately demanded, however, the starting duty is not light. It is preferable to un-









load the pump during the starting interval, by-passing the cylinders so that the water is merely circulated against the head.

Generally speaking, the only load in starting a centrifugal pump from rest is due to the bearing friction and pump inertia; both are relatively small items. As the speed increases the load increases about as the cube of the speed. If the pump is started with the discharge valve closed, the load increases as above, up to the full-speed, shut-off load.

If the pump is started with the discharge valve open, the load increases about as the cube of the speed up to full-speed, full discharge value for the then existing head. If the head on a centrifugal pump is largely static head the pump will not start delivery until well up to speed so that the starting conditions will be relatively favorable. If the head is largely friction head, as in dredging work, the pump will start to discharge at low speed and will accelerate under a relatively heavy load. It is desirable to start the larger centrifugal pumps with discharge valve closed so as to make starting easier.

Type of Control Required by Pump Motors

The form of control used for a pump motor varies with the type of motor used and the service conditions that have to be met. If the pump has to keep the level of a liquid between certain heights or between certain pressures, automatic control must be specified, and should be used in connection with float switches or pressure regulators. On the other hand if the pump is started infrequently and particularly in the smaller capacities manual control will fill the requirements.

Controllers for squirrel-cage motors on pump service may be of the compensator type, the primary-resistance type or, particularly on the smallest sizes, the across-the-line type. The compensator and primary-resistance types are made both for manual operation or for remote control, push-button operation. Fig. 8 shows an automatic compensator. The across-the-line type starter may be a manually-operated enclosed switch or an arrangement using a magnetic contactor.

Figs. 10 and 11—Motors driving centrifugal pumps are nearly always direct-connected, usually through a flexible coupling.

Fig. 10, left, shows a 300-hp., 190-r.p.m. motor connected by means of a Fast flexible coupling to a dry dock pump of the Baltimore Dry Dock & Shipbuilding Co., Baltimore, Md. Fig. 11, at the right, shows a Francke flexible coupling connecting a 450-hp. motor to the pinion shaft of a Scranton reciprocating pump.

Wound-rotor motors use a combination of a line switch or contactor and an arrangement for cutting out the resistance in series with the motor secondary. This control may be made up in the form of a manually-operated switch and drum controller or may be arranged with contactors mounted on a panel for remote control. Both of these types are illustrated in Fig. 6. The automatic type is also shown in Fig. 9. For constant-speed service, automatic control is usually preferred. If variable speed is desired, the drum controller is usually specified, although the same results can be obtained with automatic control by using a multipoint master switch.

Synchronous motors are commonly supplied with reduced voltage for starting by means of an auto-transformer or taps from the transformer supplying the power to the motor. In addition to this, control for the d.c. field excitation in the form of a rheostat and field discharge switch must also be provided. Meters giving the field current, power factor, and load current are also desirable. This control may be made up in the manual form as shown in Fig. 5 or may be entirely automatic as shown in Fig. 1.

Brush-shifting, alternating-current motors require only some form of line switch with overload protection and a mechanical means for shifting the brushes. This may be a handwheel, a shipper rod, or a small pilot motor controlled by push buttons.

Direct-current motors require a line switch and an arrangement for cutting out the starting resistance. They may be either manually operated or remote controlled. If adjustable speed is desired, a rheostat for regulating the shunt-field current is required.

Motors driving centrifugal pumps are nearly always direct-connected, usually through a flexible coupling, as shown in Fig. 10. Motors driving reciprocating pumps are generally geared through a single reduction to a crank shaft, as shown in Figs. 5 and 11. Instead of using a geared reduction, a silent chain belt is sometimes used.

Vertical motors are in common use with some types of pumps. They permit locating the pump at any depth below the motor. This may reduce or eliminate the suction lift and keeps the motor high and dry. The upper thrust bearing of the motor may be arranged to carry the entire weight on the vertical shaft if desired. If this is not done the motor drives through a flexible coupling. Vertical motors are available in squirrel-cage and wound-rotor types, and also in synchronous, brush-shifting and direct-current designs.

Some practical pointers on

Laying Out and Connecting A Pyramidal Winding

as used in three-phase induction motors, together with details of how to convert it to a two-layer diamond coil winding if necessary

By A. C. ROE
and
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Consulting Editor, Industrial Engineer

ALTHOUGH largely used by only one nationally-known manufacturer of motors, the pyramidal type of winding is now frequently encountered by repair men who have little data on its construction and method of connection. The details given in this article will be of help in laying out this type of winding and thus make it unnecessary to use an equivalent two-layer diamond coil winding. Comparative details are given, however, for both windings so as to avoid mistakes when the pyramidal winding is used or converted to the two-layer winding. The pyramidal winding is not difficult to handle or understand and it is claimed that it aids ventilation and is an easy winding in which to locate shorts or opens.

IN THIS article details are given to aid the repair shop in laying out and connecting the pyramidal winding using form-wound coils. From Fig. 1 it will be noticed that the coils are arranged in three layers and that the winding resembles the concentric chain type of winding with the exception that the coils in each group are alike.

One advantage of this winding is that the pole-phase groups of coils are all alike in size and turns so that they can be wound as a unit on a gang mold. This saves considerable connecting time, as the soldering of connections between the individual coils in all the pole-phase groups is eliminated. The only leads from any group are the starting and the finishing leads. The number of coils per group determines the number of different sizes of molds or center blocks required for winding the coils.

A pole-phase group of form-wound pyramidal coils is shown in Fig. 2. The group in this case consists of two coils, the outside coil having one-half as many turns as the inside coil. This is due to the method of overlapping the pole-phase groups as will be explained later on. This type of winding is practically a combination of the basket and concentric chain types. The lower layers must be shaped as the coils leave the slots to allow the succeeding layers to clear the coil ends. The top or last layer, however, requires very little shaping.

This type of winding also has the advantage of requiring fewer coils to be handled than in the case of the two-layer diamond type. Combinations of poles, phases, and total number of slots are possible that result in a whole number of coils per pole per phase. The total number of coils required is one-half the number of slots. Where this combination results in a mixed number, as 1½ coils per pole per phase, the total number of coils will be greater than one-half the number of slots. Examples of this will be given later. It is the number of poles, phases and slots combined that determines whether the pyramidal type of winding can be used, or whether a straight basket or two-layer lap winding will have to be used.

The long coil pitch necessary for two-pole motors, and other construction details, prevent the use of pyramidal type coils since the end windings would pile up. Anyone who has wound one of the old type Westinghouse CCL two-pole motors will understand why a two-layer winding is the best to use for two-pole motors, either two or three phase.

Other advantages claimed for the pyramidal winding are that ventilation is better as the coils are not nested together. Also, it is easier to locate and repair shorts, opens or grounds and a better opportunity is afforded to thread in a coil than is given in the case of the basket winding.

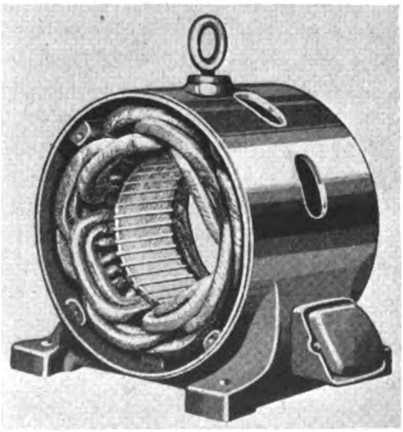


Fig. 1—How an induction motor stator looks when wound with form-wound pyramidal coils.

This is a 7½-hp., 60-cycle, three-phase squirrel-cage induction motor stator having 36 slots and using 24 pyramidal coils.

The practical range of slots used in this type of winding is from 32 to 96. Thirty-two slots are used for four-pole, two-phase motors and the 96 slots for sixteen-pole, three-phase motors having 48 coils or one coil per pole per phase.

Table No. I gives type numbers of Century motors using pyramidal coils in four-pole, three-phase designs. This table gives the total number of slots and coils, the coils per pole per phase and also the maximum number of teeth spanned by the longest coil.

The winding shown in Fig. 1 is first on the list in Table I. This winding has 36 slots and 24 coils or 1½ coils per pole per phase. This is figured as follows: for 36 slots and four poles, $36 \div 4 = 9$ slots per pole. Since this is a three-phase motor, $9 \div 3 = 3$ slots per pole per phase. In any one-coil-per-slot winding, the number of coils per pole per phase is equal to one-half the slots per pole per phase. In this case $3 \div 2 = 1\frac{1}{2}$ coils per pole per phase.

The total number of coils required equals the number of phases times number poles times coils per pole per phase. Then $3 \times 4 \times 1\frac{1}{2} = 18$. This would actually result in 18 full coils, but where we have 1½ coils per pole per phase, we will also have an overlapping of coils. Thus, there

will be a number of coils with half as many turns as there are total turns per slot.

The number of half-coils is equal to the number of pole-phase groups, or in this case, 12. The number of full-turn coils is also equal to the number of pole-phase groups. We will then have 12 full-turn coils and 12 half-turn coils. To prove this, assume that there are 30 turns per slot. Then $12 \times 30 = 360$ turns for the full-turn and $12 \times 15 = 180$ for the twelve half-turn coils, or a total of 540 turns, and $540 \div 30 = 18$, which is the number of full-turn coils found by the formula given above.

The method of arranging the coils on the stator for 1½ coils per pole per phase is interesting. There are two ways of winding the 36-slot, four-pole, three-phase stator with 24 coils. The method shown in Fig. 1 will be explained first. As

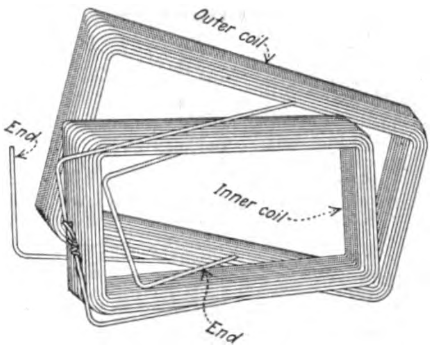


Fig. 2—A pole-phase group of form-wound pyramidal coils.
The outside coil has one-half as many turns as the inside coil.

can be seen in Fig. 1, the inside coil spans six slots, or its pitch is 1-and-7 which leaves five empty slots between its sides. The outside coil pitch is 1-and-9, or it spans eight slots.

In a chain winding the number of slots spanned by the inside coil depends on the slots per pole per phase, but in this type of winding the ratio of slots to coils determines the slots spanned and the overlap; or the number of slots minus the total number of coils equals the number of points of overlap. In the above case $36 - 24 = 12$, and since this is one-third the total number of slots, the overlap points will be spaced every third slot or slots *1*, *4*, *7*, etc.

To get the equivalent of 1½ coils per pole per phase, we can space the coil sides in four slots and allow the phase belts to overlap, or we can space the coil sides in three slots per pair of pole-phase groups and overlap the outside coils of like pole-phase groups. Fig. 1 shows the pair of pole-phase groups spread over four slots. With this method the inside coils overlap; hence the inside coils should only have half as many turns as the outside coils.

To start the winding, select a point on the stator that will bring the leads out to the best advantage and put in one pole-phase group. The inside coil in slots *3* and *9* of Fig. 3 and the outside coil of group *1* in Fig. 3 are in slots *2* and *10*. The next group, No. 2 of Fig. 3 is put in slots *11* and *19*, and *12* and *18*; the third group is in slots *20* and *28*, and *21* and *27*, and the fourth group of the bottom or A-phase layer is put in slots *29* and *1*, and *30* and *36*. The bottom layer now consists of eight coils in four groups and 16 slots. Since the inside coils are half-coils, we have eight full slots and eight half-full slots. The full slots are adjacent in groups of two, as slots *1* and *2*, *10* and *11*, *19* and *20*, and *28* and *29*. The slots on either side of, and adjacent to, these are half full.

The second or B-phase layer starts in a half-full slot, or the inside coil of group *5* starts in slot *9*, the other side being placed in slot *15*. The outside coil of group *5* is put in slots *8* and *16*. The next group, *6*, is put in slots *17* and *25*, and *18* and *24*. Group *7* is in slots *26* and *34*, and *27* and *33*, and group *8*, which is the last group of the second or B layer, is in slots *35* and *7*, and *36* and *6*. With these two layers in place, slots *1*, *2*, *7*, *8*, *10*, *11*, *16*, *17*, *19*, *20*, *25*, *26*, *28*, *29*, *34* and *35* are filled with full-turn coils.

Slots *9*, *18*, *27* and *36* are also filled by the overlapping of the half-turn inside coils of the A- and B-phase layers. Slots *3*, *6*, *12*, *15*, *21*, *24*, *30* and *33* are half full, and slots *4*, *5*, *13*, *14*, *22*, *23*, *31* and *32* are empty and these slots locate the out-

Tables I, II and III—Details of Pyramidal-Type Windings Used in Century Motors

Table I—Motor Type, 3-Phase, 4-Pole	Max. Teeth Embraced per Pole	Coils per Phase	Number Slots	Number Coils
SCI -SCIL-ASI½	9	1½	36	24
SCI½-SC3 -AS3	9	1½	36	24
AS6B-SC4 -AS5B	9	1½	36	24
AS6C-SC5 -AS6	9	1½	36	24
SC8B-SC8 -AS8	11	2	48	24
SC13-AS13	11	2	48	24
SC15-AS15	11	2	48	24
SC19-AS19-AS18	17	3	72	36
AS25L	17	3	72	36
AS30	17	3	72	36
AS35	17	3	72	36
AS40	17	3	72	36
Table II—Motor Type, 3-Phase, 6-Pole				
SCI-SCIL-SCI½B-SCIB	5	1	36	18
SC3-SC4 -SC5 -AS3	5	1	36	18
AS6B-AS6C -AS6	5	1	36	18
SC8B-SC8 -AS8	5	1	36	18
SC13 -AS13	9	1½	48	*
SC15 -AS15	9	1½	48	*
SC19-AS19 -AS18	11	2	72	36
AS26L-AS25L	11	2	72	36
AS30	11	2	72	36
AS35	11	2	72	36
AS40	11	2	72	36
Table 3—Motor Type, 3-Phase, 8-Pole				
SCI½-SC3 -AS5B-AS6B	5	1	48	24
SC4 -SC5 -AS6 -AS6C	5	1	48	24
SC8B-SC8 -AS8	5	1	48	24
SC13 -AS13	5	1	48	24
SC15 -AS15	5	1	48	24
SC19 -AS19-AS18	9	1½	72	48
AS26L-AS25L	9	1½	72	48
AS30	9	1½	72	48
AS35	9	1½	72	48
AS40	9	1½	72	48

* Basket winding used.

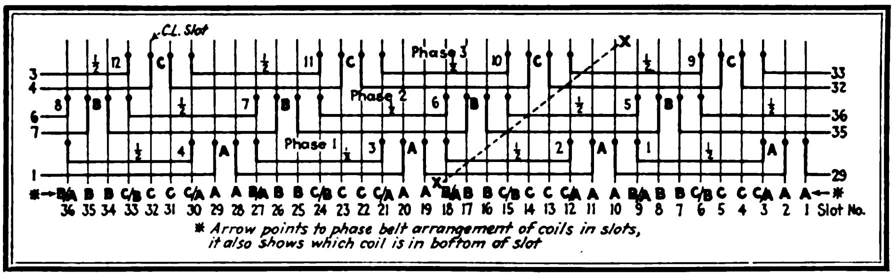


Fig. 3—Layout of a pyramidal winding for a four-pole, three-phase stator having 36 slots and 24 coils with 12 full-turn inside coils and 12 half-turn outside coils, or 1½ coils per pole per phase, with short coil pitch.

side coil sides of the third or C-phase layer. The outside coil of group *9* is put in slots *5* and *13*, and the inside coil in slots *6* and *12*. Group *10* is in slots *14* and *22*, and *15* and *21;* group *11* is in slots *23* and *31*, and *24* and *30*. The twelfth and last group is in slots *32* and *4*, and *33* and *3*.

The 24 coils and 12 groups are now all in place and the letters at the bottom of Fig. 3 show the arrangement of the phases. For example, slots *1* and *2* are used totally by A-phase coils, while in slot *3* the coil in the bottom of the slot is from the A phase and the top half from the C phase or the C and A phase belts overlap in this slot. The phase belts also overlap in slots *6, 9, 12, 13, 18, 21, 24, 27, 30, 33* and *36*, and the letter in the bottom indicates the position of the coil in each slot.

The one advantage of this arrangement of coils for 1½ coils per pole per phase is that for machines having a small number of poles, such as four, the coil pitch is shorter and thus less copper is used.

Figs. 4, 5 and 6 show the type of winding and connecting diagram that can be used to convey the necessary information for winding and connecting these motors. The vertical and horizontal lines will aid in locating the slots with reference to the line lead position. This diagram locates the pole-phase groups with reference to center lines. It also gives the proper coil pitches and the arrangement per pole per phase. This type of diagram can be used for any four-pole, three-phase, 36-slot stator with 1½ coils per pole per phase with short coil pitch, regardless of the turns per coil and the size of wire.

In these diagrams the two-in-and-one-out arrow check can be used. A separate diagram is used (Figs. 4, 5 and 6) to show each phase layout; the letters *A* indicate the line leads, as T_1 (Fig. 4), T_2 (Fig. 5), T_3 (Fig. 6). *D* is the star connection; *B* indicates the end of the first series of groups of coils equal to one-half the total groups per phase. *C* indicates the start of the second series of groups. These notations can be used to give instructions for a two-parallel star connection. The sketches in Figs. 4, 5 and 6 show a series-star connection. To change to two-parallel star, open the jumper *B-C* and connect the *B* end to the star or *D* and the *C* end to *A*. Repeat this for each phase.

Figs. 4, 5 and 6—Winding and connecting diagrams for each phase of a four-pole, three-phase stator with 36 slots.

These diagrams locate the pole-phase groups with reference to the center lines and give the proper coil pitches and arrangements per pole per phase. Short coil pitch is shown.

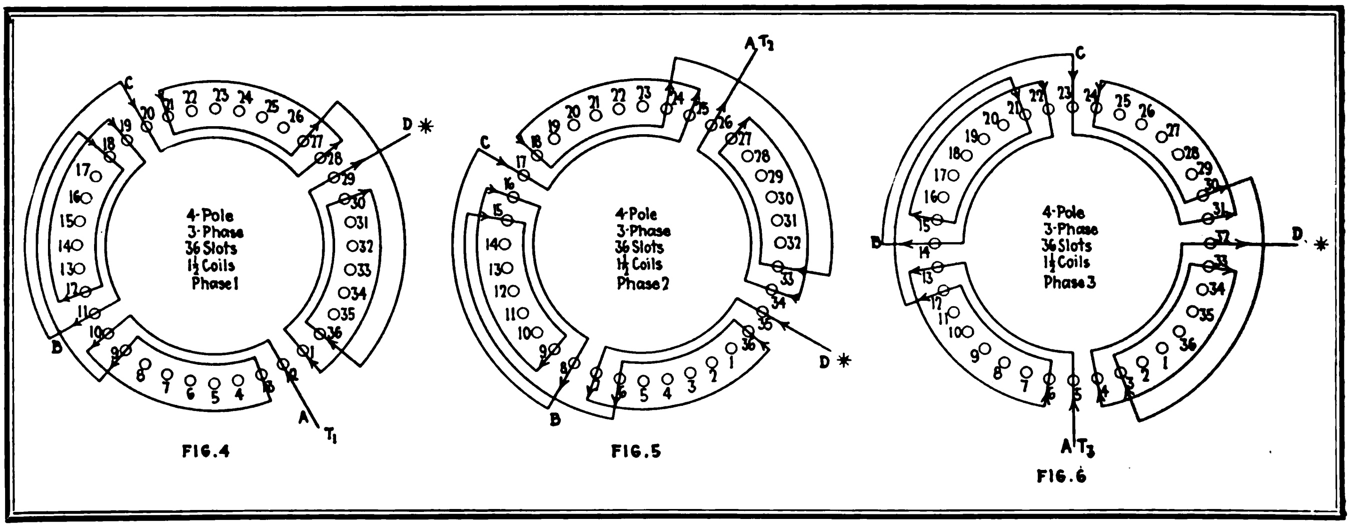
Studying Figs. 3, 4, 5 and 6 it will be found that the inside or small coils overlap in slots *3, 6, 9, 12*, etc., and that the mechanical arrangement of the coils is in four slots per pole per phase. Also, due to the overlap, the electrical arrangement is equal to 1½ coils per pole per phase. These sketches will also show that with 1½ coils per pole per phase and short coil pitch all inside coils must have half as many turns as the outside coils.

The dotted line *x-x* in Fig. 3 shows how this type of winding gets the name pyramidal. Also Fig. 1 shows how the coils are arranged in pyramidal form, or are wound on the stator in three layers or ranges.

Figs. 7, 8, 9 and 10 show the long coil pitch method of winding the four-pole, three-phase, 36-slot, 24-coil stator with 1½ coils per pole per phase. This method results in a balanced arrangement, both electrically and mechanically, of three slots per pole per phase and 1½ coils per pole per phase without the overlapping of phase belts.

With this arrangement the outer coils all have half as many turns as the inner or small coils. The inner coils span seven slots or the pitch is 1-and-8. The pitch of the outer coil is 1-and-10, or nine slots are spanned. The span of the small coil leaves six unused slots between the coil sides. The span of the large or outer coil results in these coils overlapping but only adjacent groups of the same phase overlap.

In Fig. 7 the first coil of group *1* is put in slots *1* and *8*, and the next coil in slots *36* and *9*. These last two slots are only half full after putting



in the second coil. Next, the inner coil of group *2* is put in slots *10* and *17*, filling both. The outer coil of group *2* is put in slots *9* and *18*, filling slot *9* and half filling slot *18*. Next, the inner coil of group *3* is put in slots *19* and *26* filling both, and the outer coil of group *3* is put in slots *18* and *27*, resulting in slot *18* being full and slot *27* half full. The inner coil of group *4* is started in slots *28* and *35;* then the outer coil of group *4* is put in slots *27* and *36*, both of which were half full. Thus the last coil of group *4* fills slots *27* and *36* and ends the first or A-phase layer of coils, filling slots *35-36-1, 8-9-10, 17-18-19* and *26-27-28*.

The second or B-phase layer is started by putting the inner coil of group *5* in slots *4* and *11*, filling these, and the outer coil in slots *3* and *12*, half filling these. Next, the inner coil of group *6* is put in slots *13* and *20*, filling both, and the outer coil in slots *12* and *21*, filling slot *12* since the outer coil of group *5* and *6* overlaps in this slot and slot *21* is half full. Next the inner coil of group *7* is put in slots *22* and *29*, filling both, and the outer coil in slots *21* and *30*. Slot *21* is now filled and slot *30* half filled. The inner coil of group *8* is then put in slots *31* and *2*, filling both, while the outer coil of group *8* goes in slots *30* and *3*, overlapping the outer coils of groups *5* and *7*, thus filling slots *30* and *3* and ending the second or B-phase layer.

We now have 16 coils in place in two layers, with slots *8-9-10-11-12-13, 17-18-19-20-21-22, 26-27-28-29-30-31* and *35-36-1-2-3-4* all filled, and slots *5-6-7, 14-15-16, 23-24-25* and *32-33-34* empty. These slots are used for the third or C-phase layer which starts with the inner coil of group *9* in slots *16* and *23*, filling both, and the

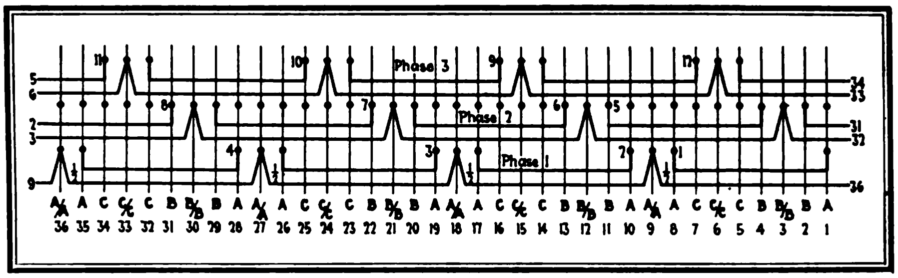


Fig. 7—Layout of pyramidal winding for same stator as in Fig. 3, using long coil pitch without overlapping of phase belts.

outer coil in slots *15* and *24*, leaving both half filled. The inner coil of group *10* is put in slots *25* and *32*, filling them, and the outer coil in slots *24* and *33*, filling slot *24* by the overlapping of the outer coils of groups *9* and *10*. Slot *33* is now half full. Next the inner coil of group *11* is placed in slots *34* and *5*, filling both, and the outer coil is put in slots *33* and *6*, filling slot *6*. The inner coil of group *12* goes in slots *7* and *14*, filling both, and the outer coils in slots *6* and *15*. This ends the third layer and the winding, by filling these last two slots, or the last coil in overlaps the outer coils of groups *9* and *11*.

The horizontal row of letters *A*, *B* and *C* at the bottom of Fig. 7 shows the arrrangement of the phase belts and also indicates how the half-turn outer coils overlap. Figs. 8, 9 and 10 give a connecting and coil layout diagram for each phase.

This long-pitch method is easier to apply than the short pitch and the winding is also easier to insulate, as the pole-phase groups do not overlap in the slot sections.

Figs. 8, 9 and 10—Winding and connecting diagrams for each phase of the winding shown in Fig. 7.

The ends of all coils in pyramidal-type windings should be taped with one layer of half-lapped treated cloth and one layer of half-lapped cotton tape and the complete winding preheated, dipped and baked. Single or double-cotton-covered and enameled wire can be used for the coils.

In Fig. 11, *A*, *B*, *C* and *D* show the winding and connecting diagrams for a four-pole, three-phase, 48-slot stator having 24 coils, or two coils per pole per phase and four slots per pole per phase. Diagram *A* in Fig. 11 shows that the first group of phase 1 or A starts with the inner coil in slots *2* and *11*, and the outer coil in slots *1* and *12*. All four slots are filled, as with a whole number 2, 3, 4, etc., of coils per pole per phase, each coil of the group has the same number of turns and the pole-phase groups do not overlap. A study of diagrams *A*, *B*, *C* and *D* in Fig. 11 will show how the coils are wound in place and connected up.

Table I also shows a 72-slot, four-pole, three-phase, motor frame. This will have 36 full-turn coils arranged in pole-phase groups of three, or there will be 12 groups, three coils per pole per phase and six slots per pole per phase. The pole-phase groups will not overlap, the coil pitches being 1-and-18 for the outside coils, 1-and-16 for the middle coils, and 1-and-14 for the inside or small coil. There must be 12 unused slots between the coil sides of the

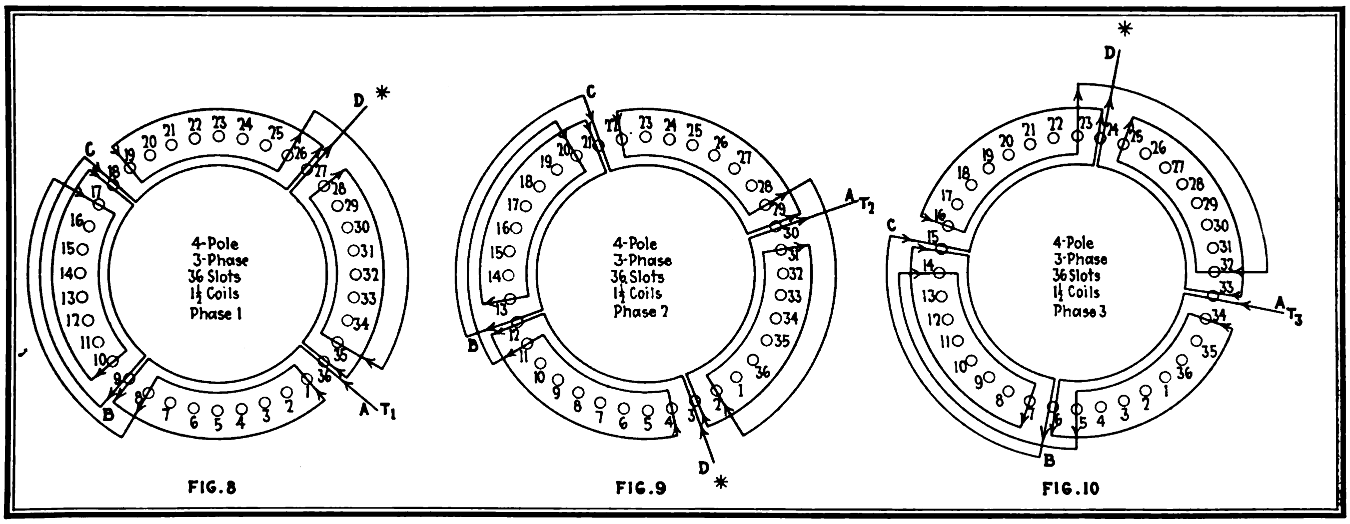


Table IV—Coil Pitches for Two-Layer Diamond Coil Winding Corresponding to Pyramidal Winding

Poles	Slots	Coils	Coil Pitch	Average Pitch
4	36	24	1–7 1–9*	1–8
4	36	24	1–8 1–10**	1–9
4	48	24	1–10 1–12	1–11
4	72	36	1–14 1–16 1–18	1–16
6	36	18	1–6	1–6
6	72	36	1–10 1–12	1–11
8	48	24	1–6	1–6
8	72	48	1–7 1–9*	1–8
8	72	48	1–8 1–10**	1–9

* Short coil pitch winding.
** Long coil pitch winding.

inner or small coil of each pole-phase group.

Table II gives the number of slots, total number of coils, etc., and the arrangement of coils for six-pole, three-phase windings. For 48 slots and six poles, three phase, the winding will be of the basket type, with odd grouping. With 72 slots, six poles, three phase, there will be 36 full-turn coils, arranged in 18 groups of two coils per group. The inside coil pitch will be 1-and-10 and the outside coil pitch 1-and-12.

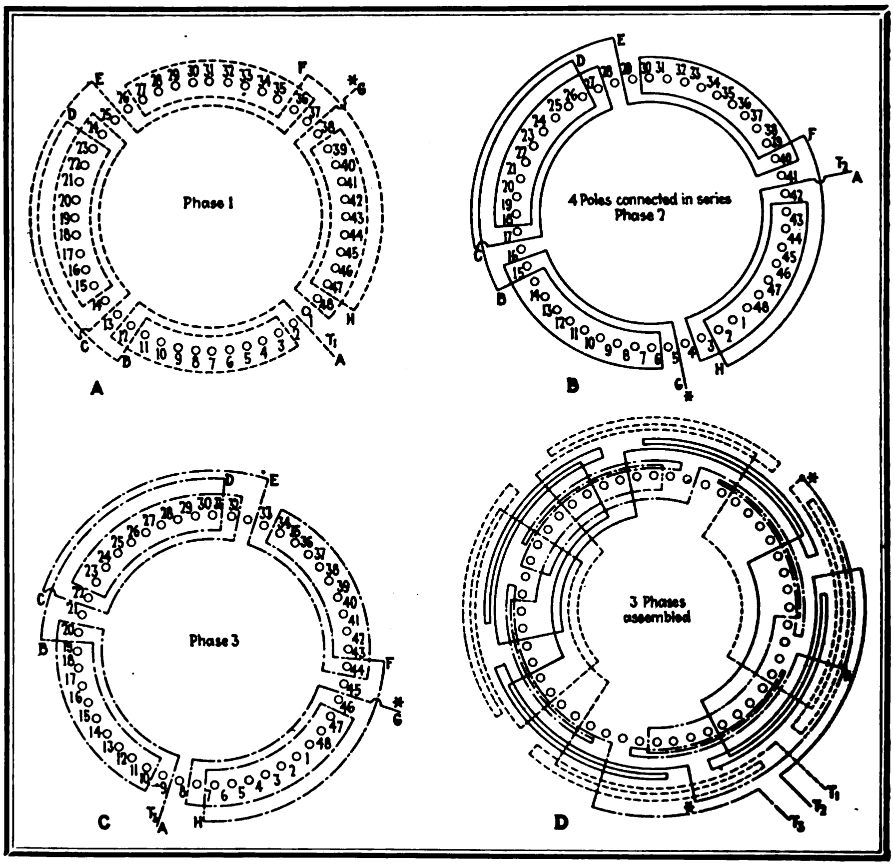
Table III shows the number of slots, coils and the arrangement for eight-pole, three-phase stators. The 48-slot, 24 full-turn coil, eight-pole winding has 24 groups, with one coil per group. The 72-slot, eight-pole, three-phase winding will have 48 coils arranged in 24 groups of two coils per group, with the inside or outside coils overlapping as in the 36-slot, 24-coil, four-pole, three-phase winding already described and shown in Figs. 3 to 10.

For those who want to change the pyramidal to the more familiar two-layer diamond coil type of winding, the following data will give the correct turns per phase, pitch, etc., to be secured from the old winding.

The first step is to count the total number of slots in the stator and the total number of coils in the old winding. Then when stripping the stator, check the number of turns per coil, or the number of turns per slot. The object is to find the total number of turns in the complete winding. Care must be taken not to count wires in parallel as turns. For example, if each coil is wound with 24 turns of two wires in parallel, there will be 48 wires per coil. The best method is to count the total number of wires per coil or slot and divide this by the number of wires in parallel per coil. This will give the turns per coil. At the same time check the pitch of the coils, inner, middle and outer, and put this down as 1-and-10, 1-and-13, etc.

Total turns per motor are equal to one-half the number of slots times the turns per slot, or the number of coils times the turns per coil. For the two-layer winding there will be as many coils as slots and the turns per coil are equal to the total turns per motor in the old winding divided by the number of slots.

Fig. 11—Winding and connecting diagrams for a four-pole, three-phase stator having 48 slots and 24 coils or two coils per pole per phase and four slots per pole per phase.



The coil pitch for the new winding will be the average pitch of the old winding and is found by expressing the pitch in slots spanned by each coil in the group, adding the pitches of all coils in one pole-phase group and dividing the total by the number of coils per group. This has been done in Table IV.

The following example will explain how this is done. Consider the 72-slot, 36-coil, three-phase, four-pole winding. This has three coils per pole-phase group, the pitch of the inner coil being 1-and-14, or 13 slots spanned; the middle coil pitch is 1-and-16, or 15 slots spanned, and the outer coil pitch is 1-and-18, or 17 slots spanned. Then $13 + 15 + 17 = 45$ and since there are three coils per group, the average pitch in slots spanned is $45 \div 3 = 15$, or 1-and-16 will be the coil pitch of the two-layer winding. The size of wire should be kept the same for both windings.

Operating conditions will determine whether all the coil ends of the two-layer winding need to be taped. If all coils are taped, a single half-lapped layer of cotton tape on each coil end will be sufficient. Treated cloth tape is not necessary with the two-layer winding since the difference of potential between adjacent coils is lower, being approximately one-half that of the old type.

We Do Not Read Enough or Well Enough

Most of us have this fault which, along with some others of like nature, can be easily corrected

Seven Sage Counsels

By Glenn Frank

For years H. L. Mencken has been flogging the south with his critical cat-o-nine-tails as the Sahara desert of living thought and the fine arts.

If the south were as much a field of charred stubble as Mr. Mencken contends, even he would have to admit that many fresh sproutings of new vitality are thrusting their way up through the stubble.

There has just come to my desk an interesting volume on "The Advancing South," by Edward Mims. It presents a fascinating story of fresh stirrings in the church, in politics, in the press, in literature, and in education in the south.

I have not yet read this volume carefully, but as I write, it lies before me and my eye lights upon a reference to one of South Carolina's contagiously alive scholars—Howard W. Odum.

Mr. Mims says of him: "Odum is as bad as Matthew Arnold in asking the most uncomfortable questions without necessarily answering them himself, but leaving the intelligent reader to give his own answers.

Such minds are priceless, for, after all, it is not the business of a teacher to be comforting, but to be disturbing; it is not the business of a teacher to put something into his hearers' heads, but to start something in their heads.

In the spring of 1924, Mr. Odum made an address at his alma mater, Emery university. He was speaking not to Georgia only, but to the whole south. He gave seven sage counsels. And I suggest that he might, with equal point, have addressed these seven counsels to the whole American people. Here they are:

"We do not know enough.
"We do not think enough or well enough.
"We do not read enough or well enough.
"We do not write enough or well enough.
"We do not do enough or well enough.
"We do not work together well enough."
"We talk too much."

The individual, the state, or the nation that does not take to heart these seven counsels will inevitably become the tool of "the demagogues and the dogmatists in politics and religion."

We must know more. There is enough knowledge lying unused in our laboratories and libraries and in the minds of the creative pioneers in politics, industry, religion, education, and science to lift the whole tone and temper of American life. It is the business of statesmanship, official and unofficial, to get this knowledge out into the open, thrust it into the stream of common thought, and make it the basis of our common life.

We must think more and read more and learn better how to put into clear and simple speech the fruits of our thought and reading. Our scholars and writers can help us here. We must breed more scholars and writers who combine the burrowing qualities of the mole with the singing qualities of the lark, men who are masters alike of the science of research and the art of expression. Too much of our knowledge has not got beyond the stage of inarticulate accuracy.

All seven of these counsels will repay careful pondering.

THE other day I found the clipping shown on this page in a daily newspaper. It set me to thinking. I wish you would read it and think a little, too, for this item contains wisdom of a rare sort. First of all, it comes from the pen of a young man, Glenn Frank, who has pulled himself up by his own efforts and mental ability to one of the highest positions in the educational world, that of President of the University of Wisconsin. Already he is well known as a lecturer and writer, and crowds of men twice his age show him the respect that knowledge of a subject merits from any man.

Glenn Frank calls attention among other things to the fact that we do not know enough, we do not think enough, or well enough, and we do not read enough, or well enough. This is certainly a bold comment, but it's true and if you are honest with yourself you will admit it. Having admitted it, you have found the reason why you are just where you are, if you are not satisfied with your success, your salary, or your job.

In the field of plant operation there is today a burning need for men who know much more than their fellow workmen; for men who possess originality, initiative and think things out by themselves. Anybody can follow the crowd, imitate the other fellow, and through years of experience learn to do a first-class job; but the fellow who is a leader must be a thinker—as well as a doer. He must read and read, to advance his own thinking.

When we started INDUSTRIAL ENGINEER more than four years ago the main editorial idea was to provide a paper for thinkers—plant operators who desire some day to be plant managers, if not plant owners. And this aim has never been abandoned. This publication has helped operators to know more—they have not only told us so but they have demonstrated it by contributing to the discussions on plant problems that appear in each issue. And their names do not appear in one issue only—they continue to appear. They are thinking more and better. They are reading more and better, and they are writing more and better. If they keep this up they are certain to know more and get a better job.

If your name has not appeared in the pages of INDUSTRIAL ENGINEER and stamped you as a thinker, then it's your own fault. The Question and Answer department invites you to take a hand in answering the problems that appear each month. How do you know but that your boss reads the answers to these questions, to locate a man for a good job he has in mind? Think a little right here and let us hear from you and put your name down in cold type as one who knows what he knows, but is ready to admit that he still does not know enough. Let's create a "We Want to Know" club and use the Question and Answer section of INDUSTRIAL ENGINEER more frequently as the means for getting the answer.

Practical Pete

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

G. A. VAN BRUNT, *Managing Editor*

Electrical Accidents Cause Far More Than Their Share of Losses

PROOF of the necessity of securing full co-operation between the electrical engineer and the safety engineer was given by Charles B. Scott, President of the National Safety Council at the annual convention of the Association of Iron & Steel Electrical Engineers held last month at Chicago.

Mr. Scott said that from an analysis of some 12,000 accidents occurring during a period of years among the 50,000 employees coming under the supervision of the Bureau of Safety of which he is Director, only 8 per cent of the total accidents were caused by electric current. However, this 8 per cent of the total accidents was responsible for 75 per cent of the total accident costs, for slightly more than 75 per cent of the total lost time, and for 75 per cent of the fatalities that occurred as a result of accidents.

These data show the importance of concentrating effort in reducing electrical hazards. This is being done in many plants. The next step is to secure better co-operation among the operating men and maintenance men connected with the operation of electrical equipment. Such co-operation can best be secured by careful selection of the men who are to do the work, careful instruction of the men on how the work is to be done and last, but most important, is constant, careful, and close supervision of the men in all matters regarding safe operation of the equipment they control.

Let the Spirit of Competition Help to Set New Records

THE desire to play, and to engage in friendly competition with our fellow men, is a very natural and deep-seated instinct whose value is greater than is oftentimes realized. For one thing, it induces us to seek that change of viewpoint and relaxation from our every-day work that keeps us interested and prevents us from going "stale" mentally. In keeping with this idea, we invent all sorts of games and contests and deliberately increase the difficulty of playing and winning them by imposing various rules which must be followed, even though there is no prize at stake.

In reality the chief purpose of these rules is to lessen our chances of winning. To the average person there is no fun in winning too easily; most of us would rather play a game that makes us exert ourselves to the limit.

This inherent love of a contest can be, and frequently is, utilized to good advantage in the conduct of business. It has been found times without number that if two or more departments or groups of men can be induced to enter into competition with each other, the morale of the men is heightened at once and noticeable progress is made toward securing increased output, a reduction in the number of accidents, or whatever else may be desired.

Naturally, any movement will be more successful if the men are given some incentive in the way of a bonus or reward, and this is usually necessary in order to sustain interest over a long period of time. Nevertheless, surprising results can oftentimes be secured when no reward is at stake, merely by arousing the spirit of competition in some effective manner.

Any executive who does not recognize and make use of this spirit in his men is overlooking a very potent force which may be a decisive factor in his own success, as well as that of his department. To arouse this force and keep it active calls for leadership and a keen sense of fair play which will see that honest effort is suitably recognized. Granting these qualifications, it is not a difficult matter to awaken in the personnel of any department, or of the entire plant, a friendly rivalry that may produce surprising results.

Are You Taking Advantage of the Progress Made in Maintenance Practice?

"ONE of the most thriving industries in any country is thinking up reasons why a new thing can't be done. That is the root of England's economic difficulty today. They've kept the old equipment so long that they can neither pay wages nor make profits on their capital. The question is not how long you can keep a thing, but how quickly you can economically scrap it. That's progress."

In these words, Owen D. Young, Chairman of the Board of Directors of the General Electric Co., states the necessity for progress. Such progress is, however, not confined to electrification of steam railroads, use of larger generating units in power houses, and similar large projects, but is also present in the commonplace but very essential work of maintaining equipment so as to keep it in continuous operation.

For instance, a few years ago it was necessary to remove rivets with a sledge and cold chisel, and pieces of shafting were sawed in two with hacksaws before replacements or repairs could be made. The oxyacetylene torch, arc welder, electric drill, air hammer and other portable tools have changed this procedure and are earning big money for those who make use of them. Sparking of commutators was thought to be a necessary evil and commutators were greased, turned, and in general had a short life until the full realization of the necessity for proper application of brushes suited to the individual characteristics of the motor or generator. Many plants have found that ball and roller bearings are able to effect maintenance savings that make them a decidedly good investment. Improved lubrication by high-pressure systems, filtering forced feed systems,

and so on, are helping to increase the life of bearings. Last, but not least, is the change in policy of the maintenance department. Instead of the "wait-until-it-breaks" attitude we find a "fix-it-first" policy in operation, with the result that operating costs and delays are being reduced.

Thinking of reasons why improved maintenance tools and methods are not required in a particular plant will never aid that plant to reduce its operating costs. Results obtained in the more progressive plants point the way in scrapping obsolete maintenance equipment and methods. At least follow the leaders if you can't set the pace.

You Can Save Trouble Later On By Overhauling Equipment Now

IN MANY lines of industry there is a more or less definite slackening of production during the summer months. This let-up affords an opportunity, which is taken advantage of in many industrial plants, to go over all of the equipment and make whatever repairs or replacements are necessary to put it in proper operating condition. In too many cases, however, such work is done only on equipment that is obviously in need of repairs; if a piece of equipment does not show any defects on a casual inspection, it is given no further attention.

This practice is all right as far as it goes, but it does not go far enough. The natural wear and tear of service give rise to many little weaknesses that are not always visible or easily detected, but which will eventually lead to trouble if neglected. Bearings become worn, windings acquire a coating of oil and dirt, contacts on control equipment become rough and pitted, and so on through a long list of defects and abnormal conditions that develop in both the electrical and mechanical elements of power drives and should not be allowed to go uncorrected.

It is a good plan to give all power drive equipment a thorough overhauling at least once a year, and oftener if possible, or if the equipment is unusually important. Thus, motors should be taken down, the windings tested, cleaned and painted, bearings checked up and replaced if necessary, and everything put into perfect condition. In the same way, control equipment and protective devices should be carefully examined and tested. Periodic checking of lineshafts for alignment will often disclose conditions that should be remedied. Belt, chain and gear drives may likewise well come in for their share of attention, as they frequently do not receive the care that they need. Now is also a good time to make any necessary changes or additions to the plant lighting system.

When properly scheduled and handled, the expense of overhauling equipment is not so great as it is sometimes considered to be. In any event, it is an effective means of reducing repair costs and preventing production delays later on when equipment must be worked to the limit.

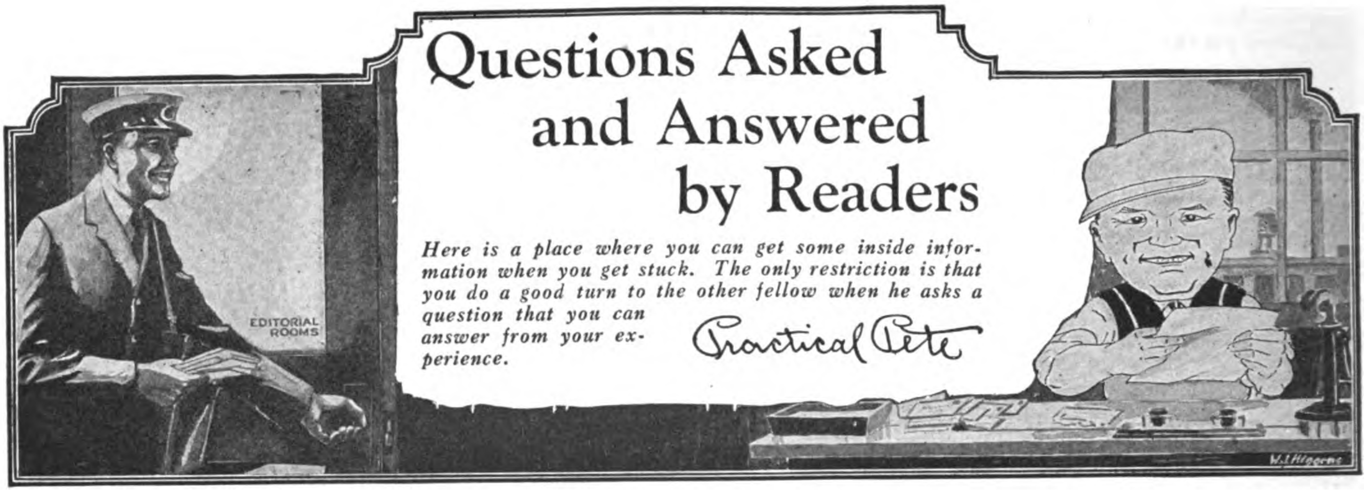
Supervision Is an Expenditure That Bears Watching

MR. GEORGE F. JOHNSON, President of Endicott-Johnson & Co., shoe manufacturers, commented in a recent article on the cost of supervision in manufacturing plants and business operations in general, and stated that the most effective way to cut costs is through cutting down the cost of supervision. He was very blunt, in his remarks on this subject, in pointing out that the all-too-common belief is that if you put a man to work at a job, it is necessary to put another over him to see that he does it and then a third man to keep a record of what is done. The result of this, he thinks, is the growing of a race of workers who are afraid of responsibility and afraid of thinking out their own tasks, and want to be supervised and directed in the most minute detail.

There is much truth in this opinion. Take responsibility for accuracy, results, or quantity of production, away from an individual and you have destroyed his initiative; and when initiative is destroyed individual thinking is replaced with mechanical movements which machines can perform with greater accuracy. In a plant where there is little opportunity for individual thinking, or a reward for it when it is of an unusual order, there is sure to be discontent; and there is no one thing that saps interest in what a man is doing like being unhappy at his work. Single out the men who whistle while they work and train these men for responsibility; more will come from your efforts than from twice as many men working in a disgruntled frame of mind.

This is no pearl of wisdom: it is an observation that any one who understands himself knows to be a plain matter of fact. The hopes, desires and ambitions of a man who works with his hands are not so different in kind from those of the man who works with his brain. Unnecessary supervision and subjection to a set level of thinking established by such supervision not only kills initiative in men but invites them to repeatedly commit errors that may not be caught until much loss has resulted in waiting for the error to reach the inspector or supervisor. Then to fire the man who committed the error is not the cure, for another man in the same position will soon, in all probability, fall into the same frame of mind toward his work.

When more leaders of industry are forced to study their production costs down deeper than the cost figures furnished to them by their supervisors, then we will find a way out of the situation that now calls for such frequent reference to labor costs as being excessive. Efficiency forced by supervision calls for an expenditure that cannot long be passed on to the ultimate user of the product made, or the service used. If you are a supervisor of men think about this and study human nature as well as the mechanical problems with which you may be forced to deal. You will learn many things that you can use to good advantage.



Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Practical Pete

Who Can Answer These?

Changing Speed of Universal Motors — Is there any way that the speed of a universal motor can be changed when rewinding? I shall greatly appreciate any information that readers can give me on this question.
Los Angeles, California. H. K.

* * * *

Burned Spots on Collector Rings—We are having considerable trouble from burned spots on the collector rings of the field of a 300-kva., three-phase, 240-volt, 25-cycle alternator. These spots are about the size of the brush faces and I am at a loss as to what may cause them. Can any readers tell me causes for this trouble and also suggest remedies for it. I shall be grateful for any information that readers can give me.
Petersburg, Va. J. W.

* * * *

Removing Flange Couplings from Shaft—Have any of our readers had experience in using an acetylene welding or cutting torch for heating and loosening solid flange couplings to facilitate their removal from shafts? If so, what type of flame should be used? Also, may tight gears and solid-hub pulleys be removed in the same way? Is there any danger of warping or distortion, due to the heating, so that the gears or pulleys will not operate satisfactorily when replaced? Should there be any difference in the treatment of steel and cast-iron hubs?
East St. Louis, Ill. M. M.

* * * *

Substitute for Crane Collector Bars—We are having considerable trouble with the collector bars on a floor-type charging crane used for charging skelp into a heating furnace. These collector bars are placed below the floor level and are reached by a collector rigging operating through a slot in the floor. We propose to do away with this method, because of maintenance troubles, and substitute a multi-conductor cable which will run from the crane to some fixed point nearby. Can some reader tell me how to rig up a device for retrieving this cable so as to prevent it from being dragged over the floor or catching on objects placed on the floor? The total travel of the crane is about 25 ft. and the cable must not be carried higher than 10 ft. in the air for there are cranes working overhead that might interfere with the cable.
Gary, Ind. F. U.

* * * *

Cause of Heating of Fuse Studs—What causes heating of fuses and studs on our switchboard panel, which is built for three-phase, four-wire distribution? The studs and fuses, which are standard make and rated at 600 amp., heat to the danger point and three fuses have been blown at a load of only 400 amp. The panel on which the studs are mounted is of slate and the spacing and carrying capacity of studs and busbars is more than the Code requires. We have aligned the studs and fuses so closely that a piece of flat steel .001 in. in thickness cannot be pushed in at any point between the clips and fuses. Suspecting loose contacts to be causing the heat, we have used wood clamps on the fuses and clips with no result. Reducing the load from 400 amp. to 200 amp. does not lower the temperature to a point permitting the hand to be placed on the fuse clips. There are no iron washers on the studs and renewable fuses of standard and reliable manufacture are in use. The neutral fuse, however, does not heat. Our voltage is 220 volts across the phases and 127 volts from neutral to any phase. Can this heating be caused by mineral veins in the slate panel? It is impossible to feel any current in the slate by wetting the hands and placing them on the slate. The heated area does not extend back more than 10 in. from the fuse studs and does not reach the main bus which is composed of two 3-in. x ¼-in. busbars. I shall appreciate your help on the problem.
Elgin, Ill. A. B. A.

* * * *

Testing Fuses to Prevent Motors Running Single-Phase—We have a large number of three-phase induction motors that are protected by individual fuses placed near each motor. Also, the different branch circuits feeding several motors are protected by fuses. To insure that the motors do not operate single-phase, frequent tests are made of the fuses. Is it sufficient to test the fuses by temporarily connecting a lamp of suitable voltage across the ends of each individual fuse? Will a lamp test across the phase wires ahead of or after the fuses give a positive indication? Will connecting the lamp ahead of one fuse and behind the adjacent fuse give a reliable indication? I should like to have some of the readers discuss these questions for me and point out which is the best method to use for testing under the conditions described and also tell how to interpret the different indications obtained from the lamp.
Newark, N. J. W. S.

* * * *

Lightning Protection for Short Overhead Power Line.—We have a 3,300-volt two-phase, 25-cycle, 80-amp. transmission line running a distance of 1,080 meters from our substation to the mouth of our copper mine. At the shaft, this line is spliced to a lead-sheath cable which goes down the shaft a distance of 200 meters where it is connected to a switchboard that supplies other feeders radiating through the mine. The wire and cable used for this transmission line are No. 00 B. & S. gage. The elevation of the country through which the line runs is approximately 4,100 meters above sea level. As the overhead line must have good lightning protection, I wish to install choke coils and lightning arresters at both ends of the line, but I have heard that choke coils should not be installed in connection with lead-sheath cables. Why is this? Won't some reader tell me how to protect this overhead line against lightning? We now have an oxide film arrester at the substation and a compression chamber multi-gap arrester at the shaft mouth, where the overhead line is connected to the lead-sheath cable. Is this sufficient protection? Should I not use choke coils both at the mine mouth and at the substation? What lightning protection would readers recommend for this transmission line?
Pulacayo, Bolivia. C. L. C.

Answers Received To Questions Asked

Method of Checking Bearing Alignment.—I should like to know how to check the alignment of bearings on machines having three or more bearings supporting the same shaft, or where two shafts are coupled together by means of rigid couplings. An example of this is a three-bearing, motor-generator set or a large, heavy-duty motor or pump having a pedestal bearing in addition to two regular bearings. I shall appreciate any suggestions that readers can give me for doing this work.
Chicago, Ill. F. B.

Referring to F. B.'s question regarding the checking of bearings, the following suggestions are offered. Assuming that the motor bedplate is level, all that is required is a straight-edge and a level. If the shaft is reduced in diameter at either or both ends, the main bearings (those supporting the largest diameter of shaft) should be checked first. To do this, the bearing caps should be removed and the straight-edge and level placed in the bottom center of the bearing. If both pedestals are not level, one of them should be shimmed, providing the bedplate does not require leveling. Next, check up the third pedestal; if the shaft is smaller in this bearing, the radius of both shaft sizes should be taken and the difference between them added to the height at which the pedestal should be set. The straight-edge should be placed in the main bearings and the distance measured to the bottom of the third bearing.

A quicker method of checking the alignment is to use a plumb line through the centers of all the bearings, shimming each individual bearing until they have a common and level center.

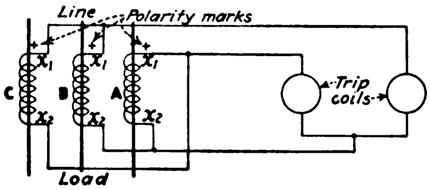
However, care must be taken in using this method, as it is very easy to shift the line. After all the bearings are lined up, the pedestals may be removed and the rotor put in place. The air-gap between the rotor and stator should then be checked with a feeler; if the rotor is not properly centered, the stator should be shimmed up or shims removed, as the case may be. The bearing pedestals should not be raised or lowered to center the rotor. After the motor is completely assembled, the shaft in each bearing should be checked with a shaft level before the bearing caps are replaced.

If the shaft is in two or more sections and connected with either rigid or flexible couplings, the main section should be lined up first. This can be done by either a straight-edge or a dummy shaft. The next section of the shaft should then be put in and leveled tc the height of the first section, bringing the two halves of the coupling together, so that they are of the same height and the same distance apart on all sides. A feeler can be used to check this point. When both sections of the shaft are level and the two halves of the coupling butt perfectly, they may be bolted together without fear of springing the shaft.

Electrical Engineer, H. E. STAFFORD.
Provincial Paper Mills, Ltd.,
Port Arthur, Ont., Can.

* * * *

Is This Relay Connection Scheme Correct?—I have a 300-hp., three-phase, 60-cycle induction motor that is star-connected to a 4,000-volt, four-wire, three-phase, power supply. Three 75-to-5 ratio current transformers are connected as shown in the diagram to the two trip coils on the circuit breaker for this motor. I believe this connection scheme is incorrect. It looks like a delta connection, but has one current transformer reversed. I think that a "Z" connection of current transformers should be used, but that is not the case here. Will some reader show me how these current transformers should be connected to insure proper protection of



the motor, and also tell me the proper current setting of the trip-coil plunger, so as to trip at 125 per cent load on the motor? Full-load rating of the motor is 39 amp. The trip coils referred to are solenoids located on the faceplate of the circuit breaker and have plungers operating directly on its trip latch.
Waukegan, Ill. S. D. H.

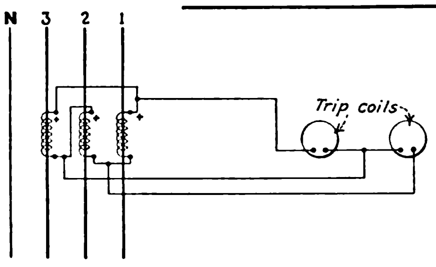
If S. D. H. will remove the left-hand trip coil from the line connecting to X_1 of transformer *A* and X_2 of transformer *C* shown in his diagram and connect it in the line running from X_2 of transformers *A* and *B*, he will have a true "Z" connection. In other words the left-hand trip coil should be connected into the line that S. D. H. shows as the common wire in the diagram accompanying his question.

The "Z" connection is an arrangement such that the resultant of two currents at 120 deg. will equal a third current which is the same as the current in the current transformer secondaries, but has a different angular relation. For the case under consideration the setting of the trip coils should be $39 \times 1.25 \times (5 \div 75) = 3.25$ amp.

C. OTTO VON DANNENBERG.
Designing Engineer,
General Engineering & Management Corp.,
New York, N. Y.

* * * *

The best protection and the one most commonly used requires three transformers star-connected to three relays, but when two relays are used the "Z" connection serves the purpose very satisfactorily. A bad feature of the delta-connected job is that specially wound relays must be used, as the currents in the relays with this connection are 1.73 times as great as that in the individual transformers, which is not true when the "Z" connection is used.



This is a "Z" connection of current transformers and relays as used on a three-phase, four-wire circuit.

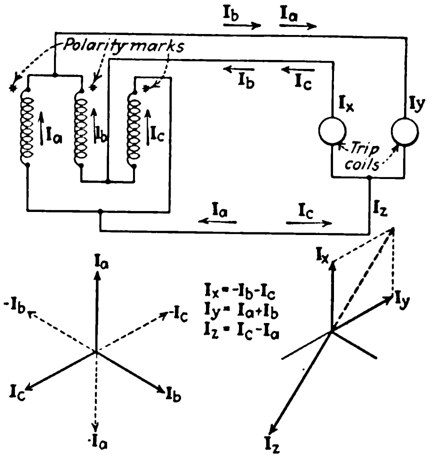
I would suggest putting in a third relay or using the "Z" connection shown in the accompanying diagram. With 39 amp. as the full-load rating on the motor, 125 per cent rating would be 48.75 amp., and with transformers having a ratio of 15:1 the secondary current would be 3.25 amp. I would suggest passing a current through the trip coil circuit, using an artificial load of 3.25 amp. and adjusting the circuit breaker trips until they operate at this current. I would then consider that I was fully protected, providing the tripping mechanism is kept in good operating condition.

E. J. MORRISSEY.
Chief Electrician,
Western United Gas & Electric Co.,
Aurora, Ill.

* * * *

In reply to S. D. H.'s inquiry I wish to say that the scheme of connections accompanying his question is incorrect. With this arrangement, under balanced conditions, one trip coil carries 8.66 amp. when the other is carrying 5 amp. For correct operation each trip coil should carry 5 amp. and a resultant current of 8.66 amp. should complete the circuit through the return wire.

The correct connection for a "Z" arrangement of current transformers is indicated in the accompanying diagram. The direction of instantaneous current flow and related vector diagrams are also shown and should be practically self-explanatory. In all such vector solutions the relative direction of current flow must always be considered. Thus, if the current flow from left to right is taken as positive (as it is in this case), then whenever the polarities are reversed the current vector must be thought of as negative. This should explain the values equated for I_x, I_y, and I_z. These three resultant currents as indicated in the vector at the right of the diagram will be found to balance out to zero and, therefore, serve as a check on the connections submitted in the diagram.



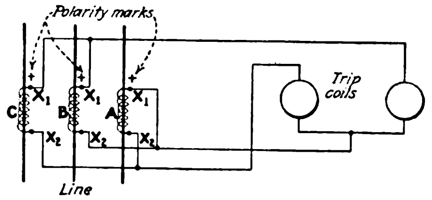
Vectorial relation of current in transformers and trip coils when "Z" connection is used.

The setting of the trip coils for 125 per cent overload thus becomes a simple matter. The current taken at that load is about 50 amp., which gives about 4 amp. through each trip coil if the current transformer ratio is 75:5, and this should be the setting used. Starting conditions must also be taken into consideration as the initial current may exceed the 125 per cent setting of the trip coils, which would then be too low.

HENRY B. HANSTEIN.
Brooklyn, N. Y.

* * * *

The connection arrangement of current transformers and trip coils shown by S. D. H. appears to have been intended for a "Z" connection and through some oversight one current transformer was connected reversed.



Interchanging the leads X_1 and X_2 on current transformer *A*, as shown in this diagram will give a "Z" connection.

The correct connections are shown above. As may be seen, the terminals of current transformer *A* are reversed so as to give a true "Z" connection.

The rule for making the "Z" connection is as follows: Connect two positive transformer terminals to the first trip coil terminal. Connect the negative terminals of the first and third transformers to the second trip coil terminal. Connect the remaining positive and negative transformer terminals to the common between the two trip coils. It will be seen that the connections shown in the accompanying diagram meet these conditions.

The "Z" connection is to be preferred to the delta connection, for with the "Z" connection when there is an overload in two lines, the current through the trip coil is the same as in the current transformers, whereas with the delta connection the current through the trip coil with an overload in two lines is equal to the current in a transformer times $\sqrt{3}$. In other words, should the current in the secondary of two current transformers of a delta-connected group reach the normal 5 amp., the corresponding current in the trip coil would be 8.66 amp. Furthermore, the "Z" connection gives better protection in the case of a short-circuit to neutral or ground in a three-phase, four-wire system than does the delta connection, which is another good reason for using it.

If the "Z" connection is used in the case under consideration, the setting of the trip coil plunger should be 3.25 amp. to trip at 125 per cent load as may be seen from the following: 39 × 1.25 × (5 ÷ 75) = 3.25 amp. This is based on the assumption that the trip coil plunger is graduated in accordance with the current through its coil.

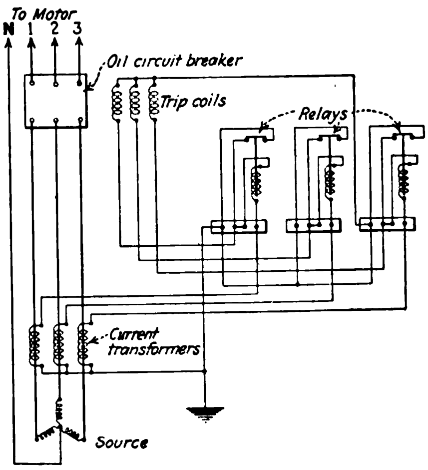
FREDERICK KRUG.

Supt. of Power Production,
Porto Rico Railway Light & Power Co.,
San Juan, Porto Rico.

* * * *

In reply to the question asked by S. D. H. if his relay connection diagram is correct, he does not show the type of relays used.

If time-limit relays are not used, the protection will be very poor, as with the trip coils set to accommodate the



A star connection of relays and current transformers may be used on a three-phase, four-wire system.

usually large starting current, he will not have running protection unless a separate circuit breaker is used for starting. If a separate starting circuit breaker is used, it will not give the proper protection unless relays are used, as a sudden change in load may cause the circuit breaker to trip. This interruption may be unnecessary, as the overload may have disappeared almost immediately.

The accompanying wiring diagram is for General Electric type PQ-3 inverse-time-limit, circuit-opening, overload relays. The inverse-time feature is used to prevent the circuit breaker from tripping during the starting period, or during momentary overloads. As the name of this relay states, the tripping time is inverse to the amount of overload, that is the greater the overload, the less the time required to operate the relay. Standard relays of this type are calibrated for 5, 8, 12 and 15 amp. with a standard 5-amp coil which will carry 5 amp. continuously. This calibration represents the minimum amperes in the relay coil which will lift the plunger and open the relay contacts.

As will be noticed, a star connection of current transformers, relays, and trip coils is used. It can be noticed from the wiring diagram that the opening of the relay contacts removes the shunt across the trip coils. This allows the trip coils to be energized, which in turn trips the circuit breaker.

In setting these relays I would advise obtaining an operating curve from the manufacturer of the relays and setting them accordingly, the trip coils being set for a slightly smaller current than the relays, so that when relays operate, the circuit breaker will trip instantaneously. Much better protection could be had by the use of a separate direct-current trip circuit from a storage battery having a potential of about 100 to 125 volts, but I do not believe your case would warrant the additional expense.

R. H. FINCH.

Chief Electrician,
Blair Limestone Company,
Martinsburg, W. Va.

* * * *

In reply to S. D. H., the following is submitted for his consideration. The scheme shown in his diagram is incorrect, inasmuch as one trip coil is connected to "Z" current and the other to delta current. The "Z" connection should be used throughout, as shown in Fig. 1 of the accompanying diagram.

An explanation of what "Z" current is may help in understanding this connection. The "Z" current flowing through the trip coil is the combination of the two transformer secondary currents of the same polarity. For a balanced load the resultant of these two currents is always equal in value to the current in the third current transformer secondary and is either in phase opposition to it or in phase coincidence. Why this is true can be readily seen from the vector diagram in Fig. 2. Vectors *A*, *B*, and *C* represent currents *A*, *B*, and *C* in the transformer secondaries. These are 120 deg. apart and equal to each other for a balanced load. Assuming the direction of power as indicated, the direction of current in the transformer secondaries will be as indicated by the small arrows. Thus, the combined currents of *B* and *C* flow toward the trip coil T_1 and the combined currents of *A* and *B* flow away from the trip coil T_2. In other words, the current I_1 through trip coil $T_1 = B + C$ and can be considered to be of positive direction, while the current I_2 through trip coil $T_2 = (-A) + (-B)$ and may be taken as of negative direction.

Referring to Fig. 2, $+B$ and $+C$ added vectorially give resultant $-A$, which is equal to and is in phase opposition to $+A$. Similarly, $-A$ and $-B$ added vectorially will give resultant $+C$.

From the inspection of vector diagram in Fig. 2 it is readily seen that:

$$+B + C = -A$$
$$(-A) + (-B) = +C$$
$$A = B = C$$

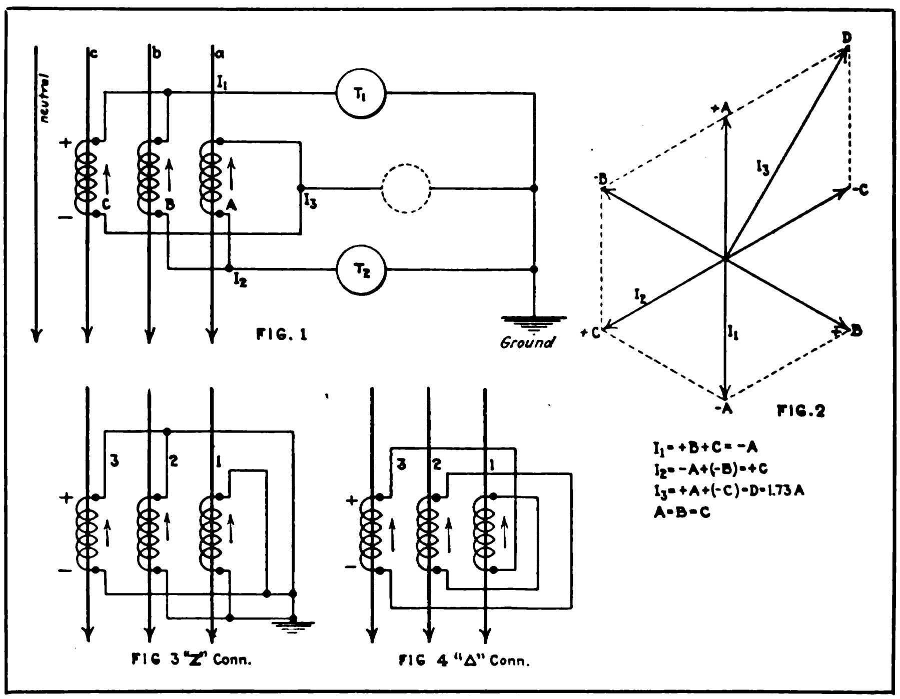
The "Z" connections utilize two positive ends and two negative ends of the three transformers, the remaining positive and negative ends are joined together and grounded. These two currents combined give delta current. This may be seen by referring to Fig. 2 from which we see that $I_3 = (+A) + (-C) = D = 1.73\ A$.

The dotted circle in Fig. 1 gives the location of the trip coil, as shown in the sketch submitted by S. D. H. For obvious reasons this connection is not practical because with a trip coil in this lead, it would receive a current equal to I_3 which is 1.73 times either *A*, *B*, or *C*, with the result that different values of current would be flowing through the trip coils, whereas the "Z" connection gives equal values through both coils.

A simple rule to remember and distinguish the difference between a "Z" and a delta connection is as follows: In the "Z" connection, shown in Fig. 3, the negative end of transformers *1* and *2* are tied together, and the positive end

These diagrams show the difference between the "Z" and the delta connections for current transformers.

Fig. 1 shows the correct "Z" connection. Fig. 2 shows vectorially why the currents in the trip coils are always equal to the secondary current from any one transformer. Fig. 4 shows a delta connection, as contrasted with the "Z" connection in Fig. 3.



of transformers *2* and *3* are tied together. The two remaining ends, the positive of current transformer *1* and the negative of transformer *3* are tied together and grounded. In the delta connection, the positive end of one transformer is tied to the negative of the adjacent transformer throughout, as in Fig. 4.

It should be remembered also that the instantaneous values are considered and due to the use of the somewhat confusing terms "positive" and "negative" it is suggested that "positive" be thought of as the power side and "negative" as the load side of the current transformer.

It will readily be seen from Fig. 1 that both trip coils carry "Z" current, which is 5 amp. at full load in the current transformer primary. This connection affords protection against shorts and overloads. Trip coil T_2 will operate on shorts between *a* and *b*, or overloads on *a* and *b*. Trip coil T_1 will operate on shorts between lines *b* and *c* and overloads on *b* or *c*. Both trip coils will operate on three-phase shorts or three-phase balanced overloads, or on shorts between lines *a* and *c*.

The trip coil setting can be obtained only by actual calibration. At transformer full load (75 amp. in the primary) both coils will carry 5 amp., while the proper tripping value for 125 per cent load is 6.25 amp. The corresponding value for the coil at motor full load (39 amp.) can be found from the proportion $75 \div 39 = 5 \div x$, x being the normal current through the trip coils at the full load current of the motor. Then, 1.25 x is the tripping value.

Solving the equation we find $x = 2.6$ amp. and $1.25 \times 2.6 = 3.25$ amp., which is the desired value.

Trip coils as a rule have a range from 5 to about 10 amp. and can be adjusted anywhere between these values by setting the adjusting nut.

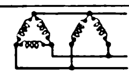
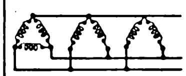
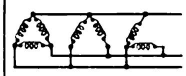
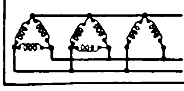
The secondary of current transformer should always be grounded.

Switchboard Section, **B. J. OPARIN.**
Westinghouse Electric & Mfg. Co.,
East Pittsburgh, Pa.

* * * *

Paralleling Open-Delta-Connected Transformer Bank with Closed-Delta Bank.—I would like to obtain the experience of some of our readers in regard to parallel operation of an open-delta-connected bank of transformers with one or more closed-delta-connected banks of transformers. Under what conditions is such operation possible? How does the load divide between the several banks of transformers? How is the capacity affected of both the open-delta bank as well as the closed-delta bank? If we have two banks of closed-delta-connected transformers operating in parallel on both the high- and low-tension sides, will these two banks of transformers continue to operate satisfactorily and divide their load in accordance with their capacity, if one transformer is cut out of one bank so as to make an open delta connection? In this particular case, all of the transformers are of the same size, voltage, ratio, reactance, and were made by the same manufacturer.
Wilmington, Del. H. E. H.

In reply to H. E. H., open-delta and closed-delta banks of similar transformers may be satisfactorily operated together in parallel, provided the load is not great enough to overload any single unit in the combination. In the case where five similar transpormers are so connected that there is an open-delta bank in parallel with a closed-delta bank, the three-phase capacity is 80 per cent of the combined single-phase rating of the five units. Thus, if we consider 100-kva. units, the actual capacity is 80 per cent of the single-phase rating, or $0.8 \times 500 = 400$ kva.

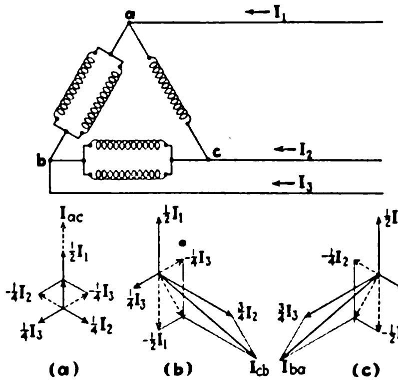
Method of connecting parallel banks	Three-phase capacity of banks in per cent of combined single phase rating	Number of similar transformers required
	80	5
	72	7
	91	7
	88	8

For different combinations of open-delta and delta banks in parallel, the three-phase capacity is different. The diagram and table give the three-phase capacity of several groupings expressed as a percentage of the combined single-phase rating. The data given assume that all units in combination are similar; that is, that they have the same ratio, impedance, and rating. **W. C. WOOLEY.**
Moloney Electric Co.,
St. Louis, Mo.

* * * *

In reply to the question asked by H. E. H., I wish to say that the capacity of a system consisting of a bank of delta-connected transformers in parallel with open-delta-connected transformers will be increased only 33⅓ per cent. This will be apparent from the following discussion.

If we have two transformers connected in open-delta for three-phase operation they will carry only 58 per cent of the kva. transformed, although we have 66⅔ per cent transformer capacity. This can be shown by letting I be the current per phase; then the line current or output current of the delta bank is $\sqrt{3}\,I$, while that of the open-delta bank is I. Hence, the output of the open-delta bank is $I \div \sqrt{3} = 0.58$ of the output of the delta bank. The transformer capacity is not used, due to the phase relationship of the currents and voltages. In the delta connection, considering a balanced load at unity power factor, the current and voltage of each transformer are in phase; but in the open-delta connection the current and voltage of each transformer are out of phase 30 deg., which results in a power factor of 86.6 per cent for the transformers. In order to have the transformers connected in open delta carry full load their combined rating must be 116 per cent of the delta, considering the delta as 100 per cent.



How the current divides in an open-delta-connected bank of transformers when connected in parallel with a closed-delta bank.

With the open-delta bank connected in parallel with the delta bank, the increased capacity is not 58 per cent, as might be expected, but 33⅓ per cent. The output of this parallel connection is limited by the rating of the delta connection. The diagram shown below will aid in clarifying the discussion. In this parallel connection, two transformers of the open delta bank are in parallel with two of the delta bank. Hence, the currents in each of the three branches will divide inversely as the respective impedances of these different branches.

Assuming a three-phase balanced load, let I_1, I_2 and I_3 represent the currents between phases *ac*, *cb*, and *ba*, respectively. Considering each phase separately, the currents will divide as follows: Current I_1 breaks up into two paths; ½ I_1 flows through branch *ac*, while — ½ I_1 flows through branches *ab* and *bc*. Current I_2 breaks up into two paths; ¾ I_2 flows through branch *cb*, while — ¼ I_2 flows through branches *ca* and *ab*. Current I_3 breaks up into ¾ I_3 which flows through branch *ba*, and — ¼ I_3 which flows through branches *bc* and *ca*. Taking the vectorial sum of these currents in each branch, there results,

$I_{ac} = + \frac{1}{2} I_1 - \frac{1}{4} I_2 - \frac{1}{4} I_3$, as shown at (*a*)

$I_{cb} = - \frac{1}{2} I_1 + \frac{3}{4} I_2 - \frac{1}{4} I_3$ as shown at (*b*)

$I_{ba} = - \frac{1}{2} I_1 - \frac{1}{4} I_2 + \frac{3}{4} I_3$, as shown at (*c*)

It must be remembered that the currents in each branch are displaced 120 deg. and that the indicated signs are vectorial signs; hence, negative vectors are reversed and added to positive vectors.

To illustrate the preceding equations, let us assume a three-phase current of 100 amp. in the line; then substituting in the equations, we have

$I_{ac} = + 50 - 25 - 25 = 50 + 25 = 75$
$I_{cb} = - 50 - 75 - 25 = 75 + 40 = 115$
$I_{ba} = - 50 - 25 + 75 = 75 + 40 = 115$

From this result it is obvious that the winding *ac* which carries 75 amp., limits the output of the system. If the delta bank were used alone, it could carry only 75 amp. However, with an open-delta bank connected in parallel with the delta bank, a 100-amp. load can be carried, which is an increase of 25 amp. or 33⅓ per cent.

FREDERICK NIMMCKE.
New York, N. Y.

* * * *

A bank of open-delta-connected transformers can be operated in parallel with one in closed delta if the characteristics of the transformers composing the banks are the same.

Consider two banks *A* and *B* operating in parallel and both connected in closed delta. If one transformer in bank *B* burns out, this bank may be reconnected in open delta and operated to 85 per cent of its rated capacity in parallel with bank *A*.

Chief Engineer, L. F. GOSS.
Kuhlman Electric Company,
Bay City, Mich.

* * * *

Are Transformer Laminations Injured by Burning off Oil and Insulating Compounds?—I will appreciate it if some readers can give me the following information: Does heating transformer laminations to remove the insulating compound and oil injure them? Is it standard shop practice to do this? How much will the iron loss be increased, if any, by this procedure? If the laminations are japanned after burning off the oil and compounds, will this cut down the core loss? Will an oxide form on the iron, during the heating, which will cut down the core loss? How hot may the iron be heated without injuring it?
Santa Ana, Cal. C. C. B.

Replying to the question of C. C. B., it cannot be positively stated that burning off oil and insulating compound from laminations will cause serious heating. If the insulating compound, which is usually some form of japan, has been burned off the safest thing to do would be to obtain new laminations. If this is too expensive or impossible the laminations should again be japanned. It is impossible, except by actual test, to tell whether the core loss is increased.

Whether this method of handling laminations should be followed or not must be left to the judgment and experience of the man in charge. While the oxide that is formed during the heating may help as an insulator, it cannot be depended upon the same as a uniform coating of japan. There may also be a change in the actual space required in stacking, due to the greater thickness of the laminations.

Heating iron to a temperature approaching a red heat causes the formation of a coating of iron oxide on the surface, thus increasing the thickness.

The writer knows of a number of jobs, where the japan and oil were burned off and the laminations restacked without any other treatment. While most of the machines seemed to operate satisfactorily, some trouble occurred which might readily have been attributed to the treatment of the iron. In the case of one large transformer a great deal of trouble in re-stacking was caused by burning off the oil and japan. Possibly too high a temperature was used for this purpose.

C. OTTO VON DANNENBERG.
Designing Engineer,
General Engineering & Management Corp.,
New York, N. Y.

* * * *

Overload Protection for Generators.—(1) We have installed in our power plant, two 2,000-kva. generators and two 4,000-kva. generators, all of which are rated at 2,300 volts, three phase, 60 cycles, 3,600 r.p.m., and are driven by steam turbines. What protection should we have on these generators? Should reverse power relays, or overload relays, or both be used? Are these relays necessary and also what other protection is required on these machines. The four machines are arranged to be paralleled together and quite often all of them are running simultaneously. (2) We have installed one 50-kw., 125-volt, motor-driven generator which operates in parallel with two 100-kw. steam-driven exciters for supplying field excitation for synchronous motors. Should we have circuit-breaker protection on these machines and, if so, should a three-pole circuit breaker be used? I shall appreciate any information that readers can give me regarding these questions.
Detroit, Mich. R. J. B.

For generator protection in the case mentioned by R. J. B., I would suggest first of all a system of grounding through a resistance, the resistance to be of such size as to conform to other points in the station; that is, of high resistance if it is desired to limit a ground current to that of the machine rating or under and of low resistance if it is permissible that the current flowing in event of ground be greater than the generator current.

The protection against internal faults is receiving more attention of late years than was accorded to it in the past and can be accomplished by low-energy over-current relays operating through current transformers placed at each end of the phase winding. With respect to the over-current relay, I would suggest that an over-current directional power relay be used. This will operate to protect against excess current in the wrong direction. An over-current relay may be added to this to protect against plain overload.

In the first case, current must flow in the wrong direction and at a predetermined value and time before the relay functions. In the second case plain overload protection is afforded.

The addition of a power relay offers a means of protecting the smaller units in the event that the larger units are accidentally kicked off or taken off the system.

A circuit breaker of the single-pole type is essential on your exciter sets. The motor driving the set should have the usual protection.

Thermal protection of bearings is not a costly item and offers possibilities in places where adequate supervision is not to be had. They can be installed to ring a signal or shut down the plant and auxiliaries. Also, it is a wise precaution to install graphic meters to record the air temperature on the intake side, with a contact-making element to warn operators in the event of too much heat as a result of the cooling system not functioning.

The use of equipment of this character may save costly repairs and expensive shutdowns.

I hope that these suggestions will be of some value to R. J. B.

Chief Electrician, E. J. MORRISSEY.
Western United Gas & Electric Co.,
Aurora, Illinois

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In regard to R. J. B.'s question about protection for a turbo-generator, it is permissible to use either overload or reverse-current relays but I do not see why both should be used. However, the overload relay should be of definite time-limit and not instantaneous. The reason for this is obvious: The momentary overloads would be continually tripping the machine on fluctuating loads.

Temperature relays are often placed in the slots of the alternator winding to prevent the machine from becoming too hot internally; these are arranged to trip the machine at a predetermined temperature.

A protective feature that is much used is the air-washing system for cleaning the ventilating air for the generators. This prolongs the life of the windings by practically keeping dust and dirt from them and also guarantees a cooler operating machine.

Should the machine become suddenly disconnected from the load and the governors unable to control its speed, the overspeed trip on the turbine should automatically shut the machine down, but the overspeed trip should be tested at regular intervals. The best time for this is when shutting down the machine because of light load. Just shift the load onto the other operating machines and then trip the breaker and let the machine speed up, while watching the speed indicator. The overspeed device usually will trip at 10 per cent overspeed.

In the last section of the question I judge that R.J.B. refers to the exciting end of the synchronous motors. In that case no circuit breaker at all is necessary, the exciters being protected by fuses rated at high overload capacity. If a carbon breaker is desired it should be equipped with a reverse-current relay. A single-pole breaker will be sufficient, but I do not see why a three-pole breaker should not be used if this is already in stock. A triple-pole knife switch may be used for the exciters. Also a double-pole switch may be used to handle the negative and positive lines, while the equalizer switch may be of the single-pole type.

GRADY H. EMERSON.
Birmingham, Ala.

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Reducing Motor Hum on Large Ventilating Fans.—In the operation of induction motors the lower the speed the greater the motor hum. In some cases however, it is necessary to use low-speed induction motors on ventilating fans and in this case excessive motor hum is objectionable since it is transmitted through the fan and to the duct system. If readers have devised ways and means to reduce the transmission of this hum by suitable mountings for motors when direct connected to the fan by using some fibrous or other material that reduces the transmission of noise, I would like to get details of such mountings. Possibly the noise-reducing device may take some form of coupling between the motor and fan. Please indicate also how magnetic density and variations in slip to get low-speed operation effect motor hum.
Omaha, Neb. H. A. P.

Replying to H. A. P.'s question, induction motors are subject to magnetic noises due to the varying magnetic densities in the iron caused by the alternating currents. I believe this trouble can be helped considerably by using sound-insulating material in the foundation directly under the motor base. Foundations of cork pads 2 or 3 in. thick, felt pads, or sheet lead are some suggestions. Some reputable manufacturers of sound-insulating materials have studied this question of eliminating the magnetic hum caused by a.c. motors, particularly with reference to elevator motors used in large office buildings, hospitals, hotels, and the like, where noise of this nature is objectionable. As a suggestion, I might say that acoustic engineers connected with some of these companies have made careful investigations of this trouble and will doubtless be very glad to furnish valuable information on this subject.

R. F. EMERSON.
Industrial Engineering Dept.,
General Electric Co.,
Schenectady, N. Y.

Electrical Service

around the works

For this section short articles describing ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing, and emergency or special installations.

Meters Used as Reverse Current Relays Prevent Racing of Rotaries

CONSIDERABLE trouble was experienced in one of our substations from the racing of two rotary converters when the a.c. voltage on the feeders supplying the converters was interrupted. Various mechanisms were tried to provide suitable protection against this condition, but without success, due to the fact that they were not sufficiently sensitive to meet the requirements.

The trouble was remedied finally by

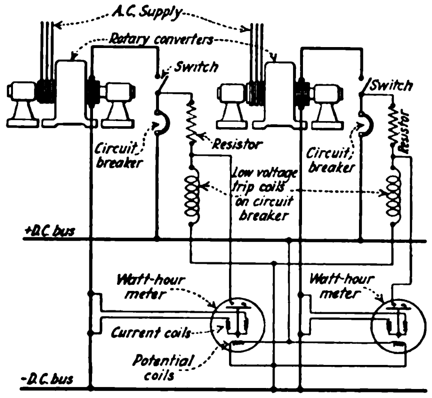


Fig. 1—Connection scheme for using watt-hour meters in the capacity of protective relays.
The meter potential coils are connected to the d.c. busbars and the current coils are connected as shunts to the negative d.c. leads of the converters. When the meter contacts are closed the no-voltage coils are short-circuited, opening the circuit breakers.

the use of two Sangamo Type D-5 d.c. watt-hour meters, one of which is shown in Fig. 2, that were arranged to act as reverse-current relays. The potential coils of the two meters were both connected across the d.c. busbars and the current coils were connected as shunts to the negative leads connected to the d.c. side of the rotary converters, as shown in Fig. 1. The armature connections for both meters were formed by using the respective sections of the two negative leads to which the current coils were connected.

The trains were removed from the two meters and leads were brought from the trip coil of the no-voltage release attachment on the circuit-breaker. Each trip-coil was connected to special contacts placed inside the corresponding meter, as shown in Fig. 2. One of the meter contacts is stationary while the other is mounted on the meter disk which is normally grounded in the mercury of the current element. A stop attached to the frame of the meter was also placed in such position as to prevent rotation of the disk in the opposite direction. By adjusting the magnets and the stop for the disk, the inverse-time limit may be varied within quite wide limits.

With the rotaries running at line voltage they are delivering energy to the line and the meters attempt to run forward, but the stop prevents this. If the voltage of one of the rotaries drops below the line voltage, there is a flow of energy back into the machine and the meter swings backward, closing the meter contact and opening the circuit-breaker by short-circuiting the low-voltage coil. This coil is in series with a resistor which prevents any damage from the short-circuit.

This arrangement has provided a most excellent type of d.c., time-limit, reverse-current relay, and has never failed to operate on interruption of the a.c. circuit on either machine. The breakers are always tripped before any variation can be noted in the speed of the converters. R. C. STEVENS.
Superintendent of Meter Dept.,
Charleston Consolidated Ry. & Light Co.,
Charleston, S. C.

Fig. 2—Sangamo type D-5 watt-hour meter provided with contacts for use as a reverse-current relay.
The disk is kept from turning by the fixed stop at the right. Upon the reversal of current flow the disk will tend to turn in the backward direction, thus closing the contact at the left, which short-circuits the no-voltage coil and trips the circuit breaker.

Methods of Lighting Finish and Assembly Work on a Moving Conveyor

THE following discussion was taken from a paper on "Automobile Body Plant Lighting," presented before the Annual Convention of the Illuminating Engineering Society at Detroit, Mich.

The paper mentioned above was written by James M. Ketch, Illuminating Engineer, National Lamp Works of the General Electric Co., Detroit, Mich., and H. J. Thompson and E. F. Labadie, Electrical Engineers, Fisher Body Corp., Detroit, Mich.

The lighting system used for the finish and assembly of the automobile body deviates from the usual industrial lighting because of the problem of furnishing proper light for work which is on a moving conveyor. How-

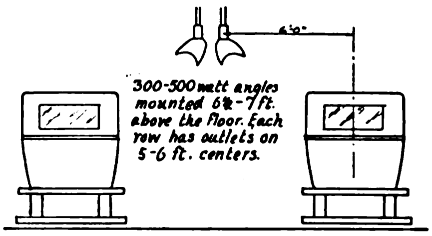


Fig. 1—Lighting arrangement for the conveyor line when work is being done on the exterior of the automobile bodies.

ever, similar applications will be found in other industries, which may be handled likewise.

The problems confronted when lighting the bodies on moving conveyors are essentially the same for the several important operations found there. The surfaces to be lighted are vertical and probably of a dark color, and the bodies are traveling at a slow but constant speed. In some plants the conveyor lines are close enough so that one side of two lines, or the bodies on both sides of the work aisle, can be lighted with one line of luminaires in the center. In many plants, however, the lines are too far apart to be effectively lighted this way, and each side of a conveyor line must be considered as a separate problem. This requires duplicate lines of reflectors in each aisle.

One company flows enamel on the bodies while they are suspended by chains from a traveling conveyor and the bottom of the body is at least 3 ft. above the floor. This body height makes it fairly easy to get proper illumination on the entire side with lumi-

naires mounted at heights of 7 to 8 ft. In other plants the bodies are mounted on trucks on a floor conveyor with the most important lower surface from 20 to 24 in. above the floor. As floor space is at a premium for automobile bodies and workmen, it seems impractical to locate any sort of lighting equipment on the floor; hence the use of low-mounted reflectors 6½ to 7½ ft. above the floor is more common than the use of those mounted at heights usual in factories.

The intensities required are high. Levels of 20 to 50 ft.-candles are standard for black, blue and dark gray jobs, while intensities of 15 to 35 ft.-candles are sufficient for work on the lighter blues, grays and gray-green color now so popular. In general, body conveyor line lighting requires special equipment and there is a wide field for the development of reflectors that will do the job with utilization efficiencies obtainable in other and more common industrial lighting systems. With the commercial equipment now available, angle reflectors seem to give the best results.

The standard of one large body company is to use 300-watt elliptical angle reflectors mounted 6½ to 7 ft. above the floor, and spaced 2½ to 3 ft. apart alternately facing opposite sides of the work aisle, thus giving an effective spacing of 5 to 6 ft. on any one side as shown in Fig. 1. Where color is very important, 300-watt, bowl-frosted daylight Mazda lamps are used, and 300-watt, clear lamps where the intensity is of more importance than the color. The elliptical angle at this height directs a high percentage of vertical illumination to the side panels and yet has a deep enough shielding angle to eliminate objectionable glare to anyone facing the row of units from the opposite side of the conveyor line.

Many schemes and devices have been tried for lighting the inside of closed bodies in the trimming and upholstering departments. While it is possible to light the body from stationary lighting systems, such systems generally prove impractical because of the need of plenty of man-space in the aisles between the conveyor lines. Where the bodies being trimmed are stationary, it is undoubtedly the most satisfactory plan to use portable extension cord or portable floor stands. In the larger plants, however, the trimming is done while the bodies move along on the conveyor line and extension cords attached to stationary outlets are generally in a hopeless tangle. The plan of lighting the dome and side-lights of the automobile by means of a third rail and sliding collector system attached to a low-voltage system has been tried. However, the voltage drop, due to poor sliding contacts and the resistance of the long steel tracks, has almost discouraged this practice.

A better plan is to install an overhead, hard-drawn, copper-wire trolley with simple sliding collectors attached to the ends of extension cords, as in Fig. 2. These collectors can be simply and cheaply made and their operation has been satisfactory. As the car moves along on the conveyor, the extension cord in the car slides the collector along the trolley, eliminating the usual tangle of cords where stationary outlets are in use.

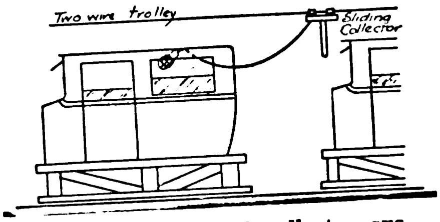


Fig. 2—Trolley and collector system for lighting the interior of the bodies when they are on the conveyor line.

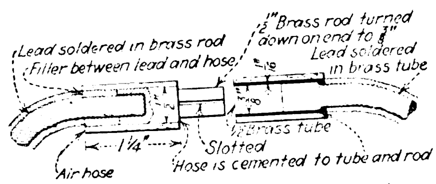
In using this device the trimmers wrap a piece of tape around the cord near the socket and tack it to one end of the wood braces in the body top where it takes care of itself until he has finished with that body. Gathering up cords and tools, the trimmer merely lifts the collector off the trolley and moves back the line to a new body. At first, the trimmers did not entirely understand the trolley system and would short-circuit the line by hanging metal gutter strips over the convenient bare trolley wires. Blown fuses or circuit-breakers are now prevented by putting two 1,500-watt lamps in parallel, and in series with one side of the line. These lamps have large enough current capacity to carry the total current of the extension cords without lighting up; yet they serve as a safety device, and indicator of trouble, by lighting if the trolley is accidentally short-circuited.

How to Make Portable Power Connector for Hard Service

AFTER trying several makes of power connectors and finding none that would stand the weather and abuse around a strip mine, I designed the one shown in the accompanying illustration.

As will be seen, this connector consists of a male and female portion, each of which is protected by a piece of ½-in. air hose. The male end is made from a piece of ½-in. brass rod which is drilled out at one end to receive the conductor. The other end of the rod is turned down to a diameter of ⅜ in. and slotted as shown. After slotting this part is is advisable to spread it slightly so that it will make better contact and be held more firmly in place.

The female end of the connector is made of a piece of ½-in. brass tube with an inside diameter of ⅜ in. The lead is soldered in the brass tube, leaving a sufficient length of the tube open to receive the male portion. The pieces of air hose, which should be about 1¼ in. long, should be cemented in place over the tube and the rod. One important advantage of the hose is that it does not warp when it becomes wet, and will stand more abuse than a fiber handle or sleeve.



Here is a portable power connector that is easy to make and has proved very satisfactory in service under severe conditions.

This power connector has proved entirely satisfactory in service and will be found very useful wherever portable cords are used under severe conditions.

R. C. VORDERSTRASSE.

Chief Electrician,
United Electric Coal Co.,
Lewistown, Ill.

Heating Caused by Carrying Each Phase of 3-Phase Circuit in Separate Conduit

IN THE February, 1926, issue, S. H. Samuels described, on page 93, the method used to correct the high temperature and unbalanced conditions caused when separate phases of a three-phase circuit were carried in individual conduits. The heating referred to was probably caused by the use of conduit made of magnetic material, constituting in effect a transformer with a one-turn secondary. The remedy that was used is essentially the same method employed for carrying connections from an electric furnace transformer to the electrodes. The conductors are so interconnected that each carries a smaller current adjacent to a line of different polarity, and the lines are grouped or interleaved, particularly when copper bars are used as conductors.

A case of trouble occurred some years ago which was solved in a different way. An iron pipe conduit system somewhat over ¼ mile in length was installed with the intention of using a three-conductor cable later on. Owing to a change to higher voltage on the system and an increase in the load to be carried, it was not possible to use a three-conductor cable that was small enough for the duct; so a single conductor had to be used. It was out of the question to draw in a single cable in each duct, due to the danger from excessive heating as well as the added inductive drop.

The matter was solved by drawing two cables of the same size and insulation into each duct. One cable ran straight through from one station to another, but the other or auxiliary cable was connected to two other auxiliary cables at the end of the iron conduit run. This gave the same result as inserting three current transformers, in three separate lines, with the secondaries short-circuited, the main cable being the primary. Since the current flowing in the short-circuited secondary sets up a magnetic field which very nearly neutralizes the magnetic field set up by the primary, the resultant magnetic field left to magnetize the conduit is small. Therefore, there is no heating, and the added inductive drop due to the section of iron pipe is negligible.

C. OTTO VON DANNENBERG.

Designing Engineer,
Sanderson & Porter,
Springdale, Pa.

Facts to Remember About Care of Renewable Fuses

A FUSE is the maintenance man's best friend, when it is properly applied and cared for; otherwise it can be the source of no end of annoyance, as well as the cause of considerable delay to important machines which it is supposed to protect. Although renewable fuses are extremely simple, there are several precautions that should be observed in using them. It is surprising, but true, that some maintenance men will install a fuse improperly and expect it to give good service. It is sometimes still more surprising to visit some power plant and note the number of fuse cases, terminals and so on laying around that have been burned up or so badly damaged that they are of no further use. I cannot say just what the life of a good renewable fuse should be, as I have never had to take a fuse case out of service, in spite of the fact that I have refilled them hundreds of times and used them in some cases at 100 per cent above their rated capacity. With this in mind, the following procedure may be of help to maintenance men who have been having trouble with fuses.

First, I always keep a duplicate set of fuses ready for use in a small rack in the power house. Under each set of fuses is marked the equipment on which these fuses are used and the rating that is best suited for its protection. When a set of fuses fails anywhere in the plant, I can replace it with the extra set in a very short time indeed.

As soon as possible, I take the blown fuses apart, polish the terminals and washers, and also the fuse links, if they are old and discolored, with a small piece of No. 00 sandpaper, and assemble the fuse carefully. I take particular care to make a good, tight fit between the link and the terminals. Right here is where a great many maintenance men make a mistake: they do not tighten the link in the terminals as well as they should, which results in a temperature rise at the terminals when the fuse is put under load. The heat is in turn passed along to the link and the result is a premature failure.

Another very important point that deserves more attention than it usually receives, is the condition of the fuse clips. I make it a point to go over all fuse clips at least once a month, remove the fuses, and carefully wipe the inside of the clips with a folded piece of No. 00 sandpaper where they make contact with the fuse terminals. After doing this I try the fuse in the clip, noting carefully whether both clips make a good, firm contact with the fuse terminals. If not, it takes only a few light taps near the base of the clip to make a tight fit. A little experience will soon enable one to do this.

Another important point to watch is whether the fuse clip is making contact with the fuse terminal on only one corner on either side of the clip. By inserting and withdrawing the fuse a time or two, one can see by looking at the fuse terminals just what parts of the clips are making contact with the fuse terminals. In a surprising number of cases, fuses make contact on just a very small part of the clip. If this condition is not corrected, the fuse cannot possibly carry its rated load, due to the fact that the area of contact is so small that it will heat up when the fuse is put into service. The result is premature failure, causing unnecessary delay and expense. Besides this, the fuse terminals and clips will probably be burned, in some cases so badly that they can not be used again. In any case, heating anneals the fuse clips and takes all of the life out of them. With the larger sizes of fuses, this heating, in addition to burning the fuse terminals and annealing the fuse clips, may also cause the fuse case to crack and split open.

All of the above instructions can be carried out in much less time than it takes to explain them. If they are complied with, it will be found that fuses will give not only months but years of faithful and reliable service, eliminating the annoyance and delay to production occasioned by premature failures due to abuse and improper care.

Chief Electrician, F. D. HEWLETT.
Ingham-Burnett Lumber Co.,
Allison, Ala.

Supposed Electrical Trouble with Hoist Motor Due to Mechanical Cause

WHILE relieving the electrician in a local plant, I was called to start a 3-ton Euclid hoist which was driven by two small, three-phase, 220-volt induction motors. One of these motors operated the hoist, being direct-connected to the drum through gears, and the other operated the bridge motion through a belt. The bridge motion motor ran nicely, which indicated a good contact on the main trolley shoes or wheels, but the hoist motor would not start. So the usual tests for blown fuses, bad contacts at trolley shoes, and an open circuit were made. All taped joints were inspected and the contacts at the reversing controller were gone over. In fact, every ordinary test was made to insure that the motor was receiving current, and all tests showed that the motor was undoubtedly getting current. The bearings were also examined, and were found to be almost perfect. The motor was in perfect shape, literally speaking, was getting the required current, but still would not run.

I took the front end bell off the motor and put an 18-in. pipe wrench on the shaft and pulled both ways, but could not move the rotor. The condition of the rear bearing showed that it was not frozen, because it was not even warm, had plenty of oil, and the motor had been running a few minutes before. A fine mill file was sent for and used to remove the burrs from the shaft caused by the pipe wrench.

We next removed the cover from the gear box. After carefully looking over the gears, it was found that a spring had become loose from its support on the load brake and had wedged between the main gear and the gear housing. This spring is used on the load brake and is about 3 in. long by $\frac{3}{8}$ in. in diameter. It had been pulled up almost its full length between the drum gear and the housing. When the spring was removed and replaced by a new one, and the front end bell again put on, the motor ran normally.

Because of a rather unusual ruling in this plant, to the effect that the electrician was not allowed to make mechanical repairs, I was merely an interested onlooker while the above repair work was being done. However, this incident impressed on me the fact that the mechanical end of a motor drive is oftentimes a source of trouble and should be carefully inspected when ordinary tests have failed to reveal the cause of supposedly electrical trouble.

Birmingham, Ala. G. H. EMERSON.

Method of Grounding Machines to Prevent Static Discharges

DISCHARGES of static or frictional electricity from machines used in manufacturing processes are always a source of annoyance and danger to the persons operating the equipment. There are cases on record where employees have been seriously injured, either directly or indirectly, by discharges of this kind.

Static electricity is generally developed on belt-driven machines that are set up on wooden flooring, or on a flooring having fair electrical insulating properties, and where the main drive shaft bearing brackets are mounted against a wooden ceiling. In many cases belts are grounded by means of metal combs placed close to the belt surface to remove the static charge.

The methods of preventing trouble from static electricity are extremely simple, and consist in grounding the frames of the machines to a suitable conductor going to earth.

There are, however, a few points to keep in mind when installing ground connections. As a rule, a ground wire is run to the nearest water or gas pipe, regardless of the conditions or the troubles that are quite likely to develop later.

Consequently a few suggestions may be helpful. In the first place, avoid grounding wires on fire sprinkler heads, steam pipes, gas pipes, meters, valves, and conduits. There is always danger of a pipe, especially a steam pipe, being insulated from the earth, or leaking gas being ignited, with the possibility of frequent repairs making the ground ineffective for certain periods. Machine ground wires should be run so that they will not be mishandled and broken, to become a hazard to employees.

A simple and effective method of grounding any number of machines is to connect them to a common copper wire, say No. 6 B&S gage, which is carried along the floor and outside the building in conduit. The conduit serves merely as a physical protection for the wire which should be soldered or welded to a copper plate imbedded in several layers of charcoal placed at a sufficient depth to be in permanently damp earth. This method is recommended by the Department of Safety and Labor in several states.

Jersey City, N. J. E. A. BAERER.

Mechanical maintenance of

Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through the auxiliary transmitting equipment to all driven machines.

How an Uneven Belt Was Made to Run True

THE defective portion of the driving belt of a high-speed, three-bearing generator was recently removed and replaced by a new piece. When the machine was started following the repair, the belt persisted in running off to one side, which brought one edge in contact with the outside bearing pedestal of the generator. This was probably due to stretching of one side of the old belt, or to a splice which was not square with the edge. It was easily seen that if this were permitted to continue, the edge of the belt would soon become stretched and worn and flare out. This would soon destroy the belt.

The difficulty was overcome by transferring the crown of the driven pulley from the middle of the pulley face to a point nearer the center bearing. A ring of ⅛-in. holes was drilled around the pulley face about 1½ in. to one side of the old crown at the place it was desired to have the new crown and a strip of raw-hide belt lacing riveted to the pulley base. When the machine was started, the belt ran true on account of the action of the new crown. The pulley was enough wider than the belt so that it did not run off at the other side when shifted over by the new crown.

Another way to build up a crown, or to shift a crown to one side of the center of a pulley, is to use cloth and some of the various pulley cements on the market. When this method is used it is not necessary to drill holes in the pulley face, nor does it leave a row of projecting rivet heads around the new crown.

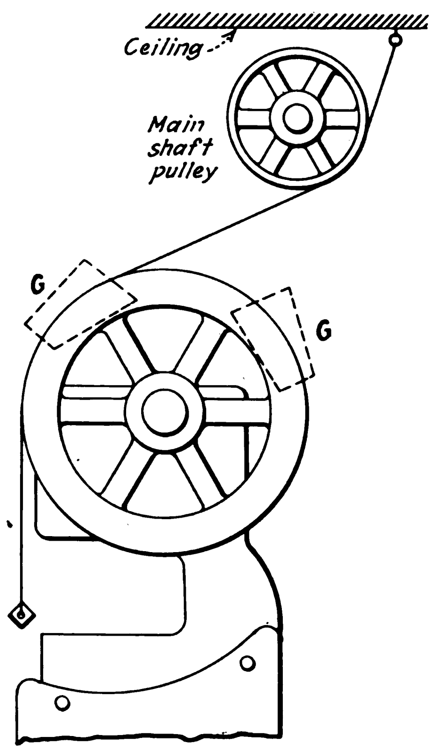
Safe Method of Lining Transmission Guards While Operating

EVERY millwright has had to do jobs after working hours because of the risk or impossibility of working around moving transmission equipment. Even the measurement of belt lengths by use of a tape over the pulleys is fraught with danger and difficulties. The accompanying drawing shows a method of doing, without risk and in a most simple manner, a job in which moving pulleys figure.

Two guards were to be applied to the belt and flywheel, which also served as the pulley, of some punch presses and attached at the points *G* and *G*. The guards themselves were of the box type which provides a bell-mouthed opening for the belt and also has sides which completely enclose the pulley and belt on the exposed sides. It is obvious that the only way to set these guards properly is to have the belt or its equivalent in position.

To attach the guard it was necessary, for safety, to have the press idle because of the danger of working around a moving flywheel. With the belt thrown off the flywheel there was no means of lining up the guard. For this reason it had been considered necessary to do the work at night. In order to avoid overtime work on this occasion, the millwright in charge threw off the belt and substituted a line, as shown in the accompanying sketch. The first step was to attach a small eye to the ceiling above the pulley on the lineshaft. A cord was fastened to this eye and carried over the moving pulley on the lineshaft and on down over the flywheel on the press. A nut on the end of the cord served as a weight to hold it in position. This cord provided him with a true belt line from which he could accurately place his guards, which were secured by angles to the frame of the machine.

Following this same method the whole battery of machines was fitted during working hours. It was necessary to have only one machine idle at a time and it was possible in every case to find periods when the machines were idle for other reasons. In addition, the whole job was done better than would have been the case at night, and by a simple, safe method that is applicable to many other jobs around moving pulleys.



By using this string instead of the belt it was possible to line up the guards during working hours and while the lineshaft was operating.

It may not be out of place to mention that this incident serves as another illustration of the fact that the most obvious method of handling a job is not always the best method. For this reason a little time spent in planning the work and deciding just how it may be done with the greatest ease and safety, all things considered, will usually be well invested.

This is particularly true in the case of operations or work that ordinarily would mean stopping equipment for a time, or that involve an injury hazard to the workmen, as in this instance. Usually one has but to calculate the value of the output of a machine or group of machines, with the wages of the operators, for even a comparatively short period of time to be convinced of the advisability of avoiding shutdowns as much as possible, when work is to be done on power drive equipment. However, pursuit of this ideal should not be carried to the point where the workmen are exposed to any unusual hazards. DONALD A. HAMPSON.

Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Comment on "Specifications for Oil and Grease Lubricants"

IN THE discussion of the sludge test in the article entitled, "Specifications for Oil and Grease Lubricants," which appeared in the March, 1926, issue of INDUSTRIAL ENGINEER the following statement appeared: "The sludge test, which determines the tendency to form a sludge, has comparatively little bearing on lubrication, but is of interest to the manufacturer and important in determining the insulating life and value of transformer oils."

Attention has been called by readers to the importance of the sludge test on an oil used in the lubrication system on turbines and other equipment where the oil is circulated continuously. This article was intended to cover only lubrication problems incidental to power transmission equipment and plant machinery. A discussion of engine and turbine lubrication is extensive enough to demand individual treatment.—EDITORS.

Determining Size of Pulley for Fabric-Base Belts

WHERE fabric-base belting is made up of several plies of stitched or cemented canvas, pulleys of small diameter should not be used because of the danger of pulling the plies loose when making the short bend.

The proper size of pulley to use with such belting of various weights and plies may be determined by means of the accompanying chart which takes into consideration working stresses ranging from 210 to 280 lb. per sq.in. The three most common weights of duck used in belts, 28 oz., 32 oz., and 36 oz., have corresponding working stresses of 220, 237 and 252 lb. respectively. These stresses are given in column *A*. Column *B* gives the minimum pulley diameter in inches and column *C* the number of plies. With this chart any of these three factors may be found if the other two are known.

The method of using the chart is best shown by an example. Thus, if a seven-ply belt is made of 32-oz. duck, what minimum pulley diameter may be used? To find this run a straight line through the point in column *A* corresponding to 32-oz. duck and figure 7 (number of plies), in column *C;* the intersection of this line with column *B* indicates that the minimum pulley diameter that should be used with such a belt is 18 in.

In other words, simply run a straight line through the working stress, column *A*, and the number of plies in column *C*, and the intersection of this line with column *B* will give the minimum pulley diameter. Extremely small pulleys must be avoided, if it is at all possible to do so. Thus, column *B* shows that no pulley smaller than 5 in. in diameter should ever be used with a standard fabric belt.

Data for Proportioning Fabric-Base Belts

Belt Width, Inches	Number of Plies, Minimum	Number of Plies, Maximum
2	2	3
3	3	4
4	3	5
5	4	5
6	4	5
8	4	6
10	4	6
12	4	6
14	5	6
16	5	6
18	5	6
20	6	7
22	6	7
24	6	7
26	7	8
30	7	8
36	8	10
42	8	10
48	8	10
54	10	12

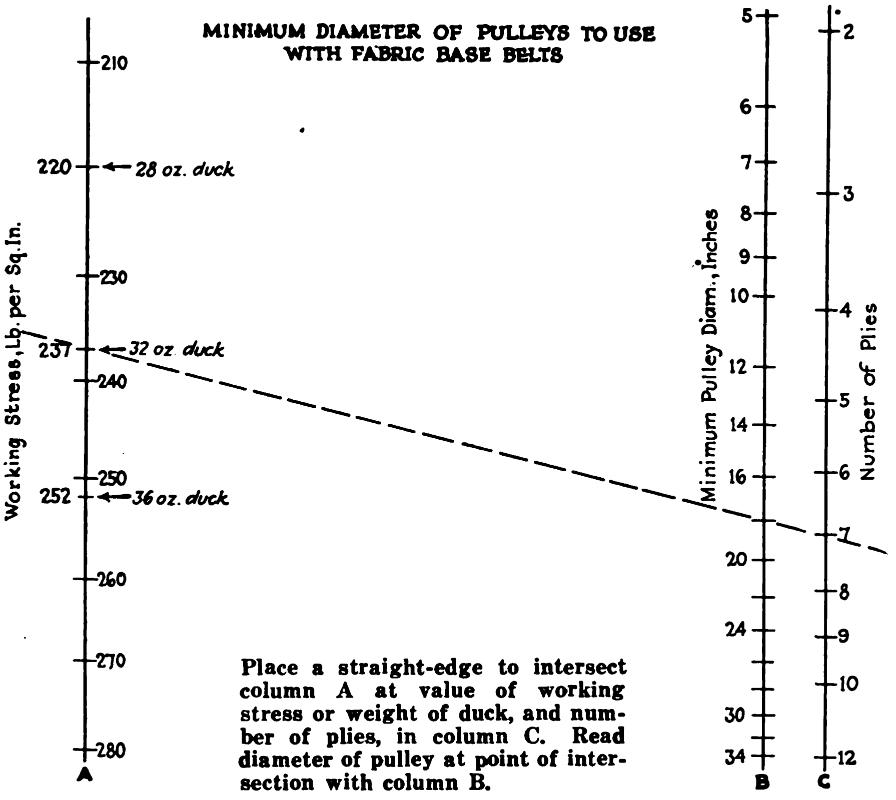
This chart is based upon the following rule: Extract the cube root of the working stress in pounds per square inch, multiply by the number of plies and divide by 2.4. The result is the minimum diameter of the pulley in inches.

This chart may also be used for determining the maximum number of plies when the working stress and the pulley diameter are known, by simply runing a straight line through the two known factors.

The accompanying table will assist in the selection of a well-balanced belt that will be neither too thick nor too thin. Thus, for instance, if the belt width is 10 in. it is generally considered best not to use less than four or more than six plies. This table used in conjunction with the chart will be found to be very useful when laying out fabric-base belt drives.

W. F. SCHAPHORST.

Mechanical Engineer,
Newark, N. J.

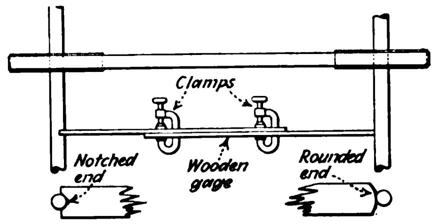


Place a straight-edge to intersect column A at value of working stress or weight of duck, and number of plies, in column C. Read diameter of pulley at point of intersection with column B.

Easily Constructed Gage for Aligning Shafts

ON PAGE 193 of the April, 1926, issue of INDUSTRIAL ENGINEER appears an interesting item by Maurice C. Cockshott entitled "An Easy Method of Aligning Parallel Shafts." I have a method that I believe is better for certain conditions, particularly where the end of the shafting is difficult of access, and for quickly checking the alignment. This method does not require any careful measuring or marking by use of a carpenter's try-square.

The equipment required can be quickly put together in any plant. It consists of two pieces of light, slender but stiff, wooden strips and two light clamps, as shown in the accompanying sketch. With a gage like this, clamped together at a length equal to the distance between the shafts at one point, it is a simple matter to check the shafts at other points and learn whether or not they are parallel. If the shafts need aligning the gage will touch only at the points of minimum distance; but if the shafts are parallel, the gage will "just touch" at both ends at every place of measurement. If one end of the gage is V-notched to fit over the shaft so that it will not slip off and the opposite end rounded, the gage can be handled more easily.



The construction and method of using a light wooden gage for checking alignment of parallel shafts is shown here.

Wooden gages are far superior to a cord because wood does not stretch or shorten according to the tension. Also, a light wooden stick can be handled with ease and certainty. It is even better than a steel tape, in that it is easier to get the exact distances between the shafts.

In almost any plant where much shafting is used, it is worth while to make a gage of this kind to keep on hand for use as a permanent tool. When fitted together with a tongue-and-groove joint the two pieces can be adjusted more quickly than without such a joint. However, two plain sticks will serve the purpose very well in an emergency.

Newark, N. J. W. F. S.

In the Repair Shop

This section is devoted to repair work on electrical and mechanical equipment. Special attention is given to shop or bench tools and short cuts or improved methods of handling work of this character. Contributions are always welcome.

How to Meet Emergency Demands for Brushes in the Repair Shop

CARBON brush stock carried by various repair shops will be found to vary greatly. The larger shops often carry a large stock of special brushes ready to place in the machine, but the stock of special brushes kept in the small shop must necessarily be limited. However, it is important that the latter be able to meet most brush needs at short notice. Any repair shop will be helped greatly in meeting emergency demands by keeping in stock a few plates of carbon from which brushes of various sizes may be cut. These plates can be obtained 4 in. by 8 in. in size and of almost any thickness desired. Carbon stock can also be secured in rods of various diameters.

Round brushes may, if necessary, be cut from plate or flat stock and if a little care is used they will be satisfactory in both appearance and service. In making a small round brush from flat stock, cut a square brush of the required length and a little larger than the diameter of the required brush. By cutting off the corners, an 8-sided or 16-sided piece may be made, depending upon the size of the brush required. If a piece of sandpaper is folded over the brush and the latter turned, the surface will soon become round and smooth. J. P. COLLOPY.

Fort Collins, Colo.

Method of Reconnecting 2,200-Volt Synchronous Motor for 440 Volts

SOME time ago in the reconstruction of an industrial plant all induction motors, which previously had been connected for 2,200 volts, had to be replaced by 440-volt motors or reconnected for this new voltage, where possible. Among those to be reconnected was a synchronous motor.

This particular motor was originally designed for 165 hp., 2,200 volts, three phase, 41 amp., 900 r.p.m., 96 slots and 48 coils, or 16 coils per phase. Fig. 1 indicates how the coils were originally connected series-star.

In reconnecting for 440 volts it was decided to use a composite delta-star connection, which is shown in the schematic diagram of Fig. 4, having three paths in the delta portion and five paths in the star portion. Using a 440-volt power supply the line current required is 41 (amp.) $\times$ 2,200 (volts) $\div$ 440 (volts) $=$ 205 amp. Since there are five paths in parallel the current in the star portion of the connection (that is, from A to E, B to F, or C to H) will be $41 \times 5 = 205$ amp. Now the phase current in the delta portion of the connection (that is E to F, F to H, or H to E) must be the line current divided by $\sqrt{3}$, or $205 \div 1.73 = 118.4$ amp. This portion of the winding, however, is capable of carrying 3 (paths) $\times$ 41 (amp.) $=$ 123 amp., from which it is seen that the current flowing in the winding is practically the same as it was before reconnecting the motor.

The original series-star connection was changed to a delta-star combination.

The original connections of the motor are shown in Fig. 1. The vector diagram in Fig. 2 shows the phase relations and voltage across any two phases when reconnected. The schematic diagram of a four-parallel star connection in Fig. 3 indicates the preliminary steps in the new connection scheme. Fig. 4 shows the composite delta-star connection with three paths in delta and five paths in star, which was required for the new voltage.

To find what the line voltage should be, let us refer to the vector diagram in Fig. 2. In the original connection of Fig. 1 the line voltage is 2,200 volts; so the voltage across each phase is $2{,}200 \div 1.73 = 1{,}271$ volts and the voltage per coil is $1{,}271 \div 16 = 79.4$. In Fig. 4, we have two coils in series between B and F, (the star portion of the winding), the voltage is $2 \times 79.4 = 158.8$, and since the delta portion between E and F is in phase with the star portion between B and F the voltage from E to B is $2 \times 158.8 = 317.6$ volts. However, AE which also represents 158.8 volts is 120 deg. out of phase with EB; so these voltages must be added vectorially to find the total voltage across AB. If the diagram in Fig. 2 is carefully drawn to scale, it will be found by measuring that the voltage from A to B, B to C, or C to A, is nearly 415 volts, which is close enough to 440 volts for operation.

An easy way to make this connection is to draw the schematic diagram for the four-parallel star connection, as shown in Fig. 3, with equalizer connections at a, b, c. Now place the coils g, e, f, of Fig. 3 at g, e, f, in

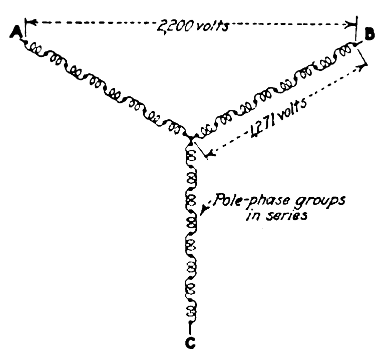


Fig. 1

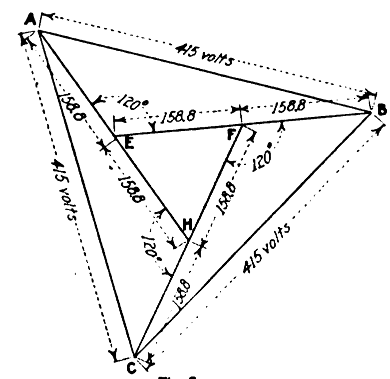


Fig. 2

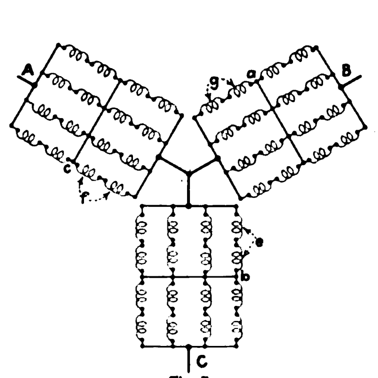


Fig. 3

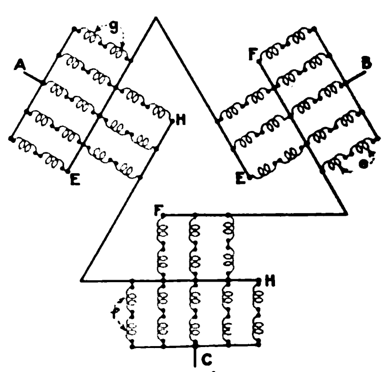


Fig. 4

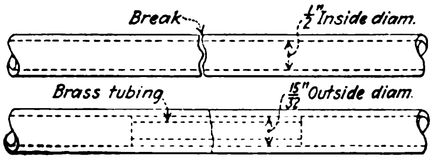
Fig. 4 thus locating them between the line leads and equalizer connections and making five pole-phase groups in parallel.

The star connection in Fig. 3 is now broken and the star leads connected to the equalizer lead of the adjacent phase, as shown at *E*, *F* and *H* of Fig. 4. This results in connecting the pole-phase groups between *H* and *E*, *E* and *F*, and *F* and *H*, to form the delta portion of the winding.

W. L. STEVENS.
New Westminster, B. C., Can.

Method of Reinforcing Light Metal Tubing Before Welding

AMONG the miscellaneous repair jobs which the industrial maintenance department is frequently called upon to handle, is the welding of broken steel and brass tubing. This is a troublesome job because the walls of the tubing are very light and melt quickly under the heat of the welding equipment. The result is an ever-enlarging hole. A method of over-



Using an inside sleeve enables the operator to weld light tubing without burning the metal.

coming this, as recommended by The Linde Air Products Co., New York City, is shown in the accompanying sketch.

In this instance, when welding a piece of tubing ½ in. inside diameter, a short length of 15/32-in. tubing, outside diameter is slipped inside of it. This makes an inside sleeve which provides a backing for the weld. If acetylene welding is used, it is recommended that a ⅛-in. bronze rod and a small flame with little heat should be employed on steel tubing, as the metal is thin. If the tubing is of brass, a ⅛-in. brass welding rod is recommended.

Rewinding Job Simplified by Changing Coils

QUITE often in rewinding armatures, the construction of the coils is such that a large number of reels of wire are required. Many individual reels of wire require considerable floor space and, if the wire is small, much difficulty is encountered in the subsequent handling of the coils throughout the various operations. The following discussion will describe how a good-sized order was obtained by carefully checking the coil construction and using a method of improving it.

The armatures quoted on for complete rewinds were for 50-hp., 500-volt, series, d.c. motors, and the minimum number specified was 12 per year. We were allowed to inspect the armatures at the customer's plant and upon asking for a sample armature coil, were given one that had recently come from the manufacturer. Inspection showed that these armatures had 31 slots and 155 bars and that each single coil was wound with two turns of three No. 14 d.c.c. wires in parallel. Since there were five single coils per winding unit, each coil would require 15 reels of wire to wind it. The coils were of the diamond, mush or pulled type with leads on the bottom and three wires in one sleeve or six wires in each commutator neck. In each slot there were five single coils containing six wires each, or a total of 30 wires placed five wide and six deep.

The insulation on this sample coil consisted of one and one-half turns of 0.01-in. treated cloth wrapper in the slot cell on the top and bottom sections of the coil. The outside cotton tape was 0.007 in. by ¾ in., which was wound half overlapped over the entire coil. Before pulling the coil into shape, 0.004-in. fiber strips were placed between each single-coil layer of six wires; then the coil was pressed and pulled. A layer of 0.0045-in. by ¾-in. cotton tape was applied sparingly on the ends of the slot sections and the coils were brushed with shellac, to hold the wires in place. The sleeving was tied at the end of the slot section with twine.

This customer had been rewinding his own armatures but the winding foreman found that they always had trouble in doing it. As the crossed wires in the coil ends were large, the necessary pounding to get them in place often shorted the turns. These motors were worked hard, quite often carrying considerable overload for a number of hours; consequently, a rewind did not last very long.

The first step in figuring for the job, was to find a way to reduce the number of wires in hand and to stiffen the coil. This led to the consideration of a ribbon wire which would have the same bare copper thickness as before, in order that the same size of slot could be used in the commutator necks. Accordingly, the copper would have to be 0.064 in. thick and not wider than $3 \times 0.064 = 0.192$ in., which would require at least 10 per cent more copper.

On checking a local supply house, it was found that they had only a stock size of 0.064-in. by 0.182-in. bare wire having 14,100 circ.mils area on which we were able to obtain quick delivery. Now, the three 0.064-in. wires in parallel had an area of $3 \times 4{,}100$ or 12,300 circ.mils; then the 0.064-in. by 0.182-in. wire had $(14{,}100 - 12{,}300) \div 14{,}100 = 0.127$ or 12.7 per cent more copper. Using the 0.064-in. by 0.182-in. d.c.c. ribbon wire meant that only five reels of wire would be required in place of the 15 which were used formerly, and the coil ends could be kept solid and square. By spacing the finishing tape in the slot section, we were able to use a 0.015-in. fishpaper insulation between turns in the slots and also around the rear of the loops, in addition to a 1½-turn mica and fishpaper wrapper.

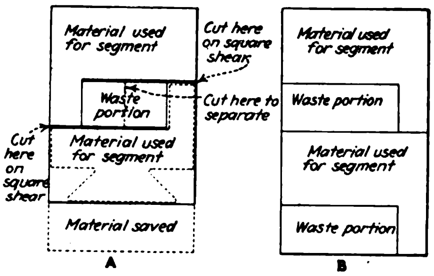
The customer approved the new winding, as was expected, and the number of rewinds per year were decreased as a result of the different coil construction.

A. C. ROE.
Wilkinsburg, Pa.

Method of Cutting Mica Segments to Save Time and Waste of Material

WHEN making mica segments for repairing commutators the usual practice is to take a rectangular piece of mica the approximate length and width of the segment, and laboriously shape it with a hacksaw and file. It is, of course, necessary to saw and file the dovetails to shape, but a saving in mica and labor on radial-type commutators is made possible by cutting two segments at one time with the square shear, usually found in a repair shop. Diagram *A* in the accompanying illustration shows the new method of cutting out segments, while *B* indicates how it is usually done.

After the mica has been cut into rectangular shape of sufficient size for two segments, the gage on the square shear is set the right distance from the



The segments are laid out and cut as shown in *A*

B indicates the waste of material caused by cutting the segments in the usual manner.

blade to form the body portion of the segment, and a cut is made approximately the length of the wearing surface. It is best to block the blade of the shear so that it will not cut off the riser portion of the segment. This can be done with a wooden block, or if there is much cutting to be done it is better to make an adjustable stop with a screw fitted into the bottom of the blade guide. It will be necessary to experiment a little with some scrap pieces of mica to determine the amount of blocking required. One will find it better to have the slit too short than too long as the radial portion must not be cut into or it will break off. The mica strip is first cut the length of the wearing surface as outlined on one segment, and then reversed and cut from the opposite side for the other segment. The small strip between the two segments should be cut with a pair of hand snips; this will separate the segments and the balance of the strip may be removed by cutting the proper distance from the end of the segment to make the radial portion.

This method has the advantage of giving a straight cut edge which is practically impossible to make with a hacksaw. It will also be noted that there is quite a saving in the amount of mica required by the new method in comparison to the old method of making one at a time. None of the manufacturers of mica plate recommend cutting it with square shears, but my experience has been that the damage done to the segment is negligible.

Cleveland, Ohio C. B. KECK.

New Equipment

for plant operation and maintenance

Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these new devices which are designed to improve plant operation or reduce operating and maintenance costs.

Cast Aluminum Floodlight with Chromium Reflector

CHROMIUM-PLATED reflecting surface, light-weight and airtight construction are the outstanding characteristics claimed for the new cast aluminum floodlight manufactured by the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa. This floodlight, it is stated, is particularly well adapted to railroad, roundhouse and industrial plant use. The chromium-plated surface of the reflector, according to the manufacturer, lengthens the life of the reflector and is economical because it eliminates the necessity of delicate care that is essential with other types of surface; it is possible to wipe off dust with gritty waste and still not damage the reflector. The chromium-plated surface has high reflecting properties, will not tarnish or break and is not subject to corrosion from either sulphur fumes or water vapor.

One of the features of this new floodlight is its light weight, with its rugged and sturdy construction. This floodlight is practically airtight and weatherproof and so prevent moisture and dirt from entering. This feature is obtained by sealing the lamp and reflector chamber. In this way the initial efficiency is maintained over long periods of time without any great upkeep costs.

Large Portable Universal Saw

MANUFACTURE of the new, large Wallace Portable Universal Saw has been announced by J. D. Wallace & Co., Chicago, Ill., as the latest addition to this company's line of portable woodworking machines.

This is a portable floor type of universal circular saw that combines advantages of the portable bench machine and the self-contained floor type. The one-way castors make it easy to move from one department of the shop to another. The motor and all working parts are built into the upper portion with the table and fences; thus the top part is a complete, self-contained, bench-type saw when lifted off the regular stand. When it is desired to take the saw out on a job, and it is not convenient to take the regular cast-iron stand, the saw can be taken without its base, and placed on any substantial wooden stand that can be easily made in any shop.

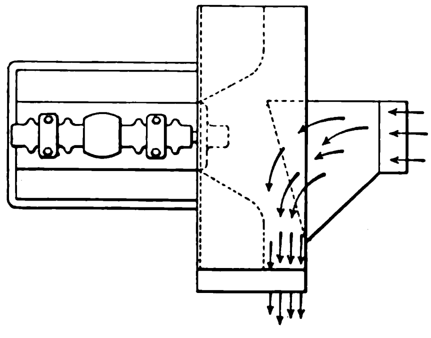
A high-grade, constant-speed, 1-hp., three-phase motor is directly geared to the saw spindle, thus eliminating belts. Ball bearings on the motor are provided with an adjustment for taking up any play. Saw spindle bearings and gears are automatically lubricated by a splash oil system.

This machine, it is stated, is designed to handle small and delicate work accurately, safely and quickly, and yet is rugged and powerful enough to cut rapidly 2¼ in. stock. Utilizing the various adjustments it is also capable of cutting compound miters, grooves ⅜ in. wide and 1 in. deep, moldings, groove-and-tongue, and so on, by means of a special dado head. To cut various angles the saw is tilted up to 45 deg., instead of the table, so that the operator is always working on a table that remains in a horizontal position.

Exhaust Fan for Conveying Fine Material

EXHAUST fans of an improved type for conveying finely divided materials by means of air have been placed on the market by the Connecticut Blower Corp., Hartford, Conn. The principal features of the design are shown in the accompanying illustration. Instead of the inlet being placed at the center of the wheel, it is placed near the periphery of the rotor and adjacent to the outlet. A flare in the inlet pipe toward the discharge opening is also provided. The result is that the material conveyed by the air is discharged immediately without being passed through the wheel and around the casing. The purpose of this arrangement is to reduce the wear on the wheel and the housing and clogging or unbalancing of the blades.

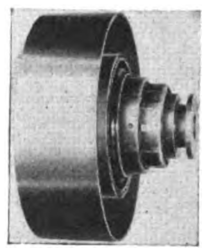
Each wheel contains 16 blades that are riveted to a steel cone and a heavy hub. The air set in motion by the rotor rushes past the projected suction opening and creates a suction therein and simultaneously pushes the material-laden air toward the outlet. The combined effect is sufficient to produce a pressure of 12 in. of water in the discharge pipe, according to the manufacturer.

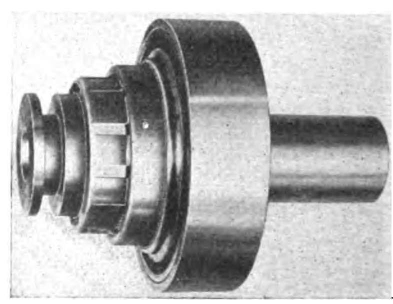


The fans are constructed almost entirely of steel. The belt-driven models are equipped with double-row, self-aligning ball bearings. Direct-connected motor types may also be obtained. The fans are made in 11 sizes, either single or double, with inlet diameters ranging from 9 to 33 in. The smallest single-rotor fan weighs 220 lb.; the largest double-rotor fan weighs 2,200 lb. The fans are reversible and the inlet and discharge connections may be arranged in various positions; also they may be mounted on the floor or bolted to the ceiling. It is stated that the fan will handle any material that can be conveyed by air.

New Disc Clutches

MANUFACTURE of a new disc clutch has been announced by the Edgemont Machine Co., Dayton, Ohio. This clutch, which is known as type E, is of the dry-plate type and is lined with renewable woven-asbestos metallic liners. The clutch is fully enclosed with the exterior completely finished. According to the manufacturer, there is a single adjustment from the outside which is made by loosening a screw in the yoke, turning the adjuster one notch, and then tightening the screw. It is stated that a uniform adjustment is made with the result that the load is evenly distributed. The levers have roller cam contact which makes for easy operation and the elimination of wear. They are so designed, it is said, as to release instantly at all speeds.





This clutch is particularly adapted for machine applications, high-speed operation and on group drives. The new clutch is being made in a complete line of pulleys, extended sleeves and cut-off couplings with slotted cams, or cams for operating through the shaft. The accompanying illustrations show a clutch pulley with cast-iron oil sleeves (above) and a cut-off clutch coupling. These clutches are equipped with Fafnir transmission ball bearings, Hyatt roller bearings and cast-iron and bronze oil sleeves.

Standardized Drum Controllers

NEW, completely standardized lines of drum controllers embodying new features of construction and comprising units for general purpose, crane hoist, or machine tool applications, for either direct or alternating current, have been announced by the General Electric Co., Schenectady, N. Y. In each group several sizes have been provided to cover a wide range in motor ratings; the small sizes are suitable for wall mounting and those for larger motors, for floor mounting.

A number of distinctive advantages are claimed for the new line. One of the particular features is in the mechanical construction, a skeleton type of frame being used. This consists of a cast cap plate and base to which are hot-riveted rectangular steel bars, thus making it unnecessary, it is said for the back of the switch to function as a framework for holding the top and bottom of the switch together. As a result, the switch is accessible from both back and front for the purpose of making adjustments and renewals.

Another feature, said to be particularly valuable in crane service, is the interchangeability of operating handle mechanisms. A vertical operating lever or a spring return mechanism may be substituted for the horizontal lever with which the switch is equipped by using another dial plate.

New style, self-aligning contact fingers are used. By standardizing the renewable copper tips for all switches of the same capacity, renewal stocks will be reduced to a minimum. Where cross-arcing is likely to occur, preventive barriers and blowouts are provided. Auxiliary contact fingers are provided for control circuits to the line protective switch. The arrangement of those circuits is designed to suit the service requirements of the installation.

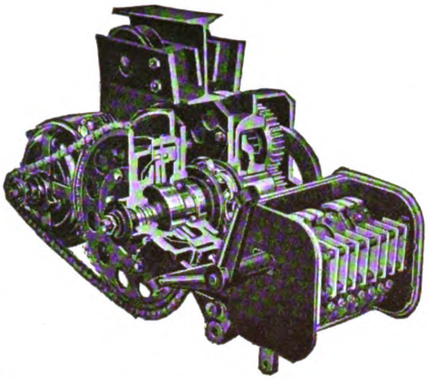
Electric Chain Hoist

ANNOUNCEMENT is made that the Yale & Towne Manufacturing Co., Stamford, Conn., has recently extended its line of electric chain hoists by the addition of the model B-20. This unit is built in capacities of ½ to 2 tons and is designed to provide for close headroom, long lift, higher speeds and greater over-all strength than are found in the former models built by the company.

The suspension member of the hoist, according to the manufacturer, is centralized to give a balanced load on the trolley wheels and hoisting unit, irrespective of the load position. The side plates of the trolley carriage can be spaced to fit the desired beam flange.

The hoist mechanism is inclosed in an oil-tight chamber and is said to be readily accessible for inspection and repairs. The load sheave is carried on large chrome-vanadium steel ball bearings and is bronze-bushed for the driving pinion, which is machined from a single drop forging and heat-treated. All gears, pinions and bearings are splash-lubricated.

Chain containers can be furnished to hold any length of slack chain up to



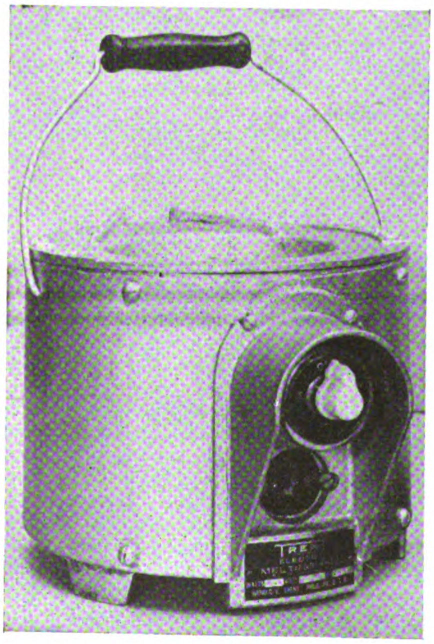
60 ft. for the hoists up to 1-ton capacity, and up to 30 ft. for the 2-ton hoist. These containers are secured to the underframe of the hoist and do not affect the headroom.

Dust-Proof Meter Case

A ONE-PIECE, mahogany-veneered, Micarta, portable meter case has been designed by the Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa., for standard watt-hour meters. This case is said to be strong, to resist acids and is of dust-proof construction. It is made in one piece with its inner layers of the same Micarta that is used for industrial gears. A tightly fitting, nickel-plated brass ring, lined with felt prevents any dust from entering the box once the meter is inserted. A lid of the same finish as the box protects the meter when it is not in use.

Large Capacity Melting Pot

THE line of melting pots manufactured by Harold E. Trent, 250-251 N. Lawrence St., Philadelphia, Pa., has been extended to include a 45-lb. pot controlled by a three-heat switch and separable plug connection. This pot, which is shown in the accompanying illustration, has been adapted not only for ladle and dipping work, but also for



pouring, as a spout and handle are part of the standard design.

The pot, it is stated, is suitable wherever solder, babbitt, tin or lead is melted, and where rapid, economical heating and sturdy construction are a necessity.

Oil-Filtering Equipment

EQUIPMENT for filtering and removing water from transformer oil or any other oil from which it is important that all water be removed, has been announced by Wm. W. Nugent & Co., 410-412 N. Hermitage Ave., Chicago, Ill. It is stated by the manufacturer that this filter may be cleaned or inspected without stopping the continuous filtering process. For cleaning or inspection the filter bags may be drawn out at the front of the filter, in a manner similar to removing a drawer from a desk. Doors in the front of the cabinet may be opened and the filter bags completely exposed.

Another new type of filter is designed to clean any kind of lubricating or cutting oil that is free from water. It consists of a series of filter-cloth bags suspended from a suitable rack. A steam pipe or electric coil heats the dirty oil as it enters so as to reduce the viscosity and thereby increase the rapidity of the separation of the foreign matter. The filtering process is continuous.

The bags may be quickly removed by raising the cover and lifting the frame off the rack. They should be washed in hot soapy water or kerosene. An automatic bell alarm notifies the operator when the bags require cleaning.

This type of filter is made in 27 sizes ranging in capacity from 40 to 2,000 gal. per hr. and employing from 1 to 40 bags. The filtering surface ranges from 7 to 336 sq.ft. The over-all dimensions for the smallest size, which weighs about 200 lb., are 17 in. by 27½ in. by 46 in.

New Switchboard Fixtures

A NEW line of adjustable supports for wiring installations for permanent or temporary work, and which may be used on timber, masonry, structural steel or pipe framework, has been placed on the market by the General Electric Co., Schenectady, N. Y. The rods, of ½-in. cold-rolled steel which may be cut to any length, are used with two forms of supports: the wedge-shaped castings for pipe, or a slotted casting to fit the edge of I-beam flanges. A clamp in the form of an elongated U (a short piece of strap iron turned up at the ends) is used to clamp the rods to the supports. This clamp is also used in clamping apparatus to the rods. The slotted castings for I-beam flanges may also be used on flanges of most of the conventional structural steel shapes. The support is fixed in position by means of a setscrew, which also allows the ready removal of the support at any time. By substituting lagscrews and round spacers in place of the supports the fixture may be used in wooden timbers or planking. Expansion bolts and spacers adapt the fixture to brick, concrete or other masonry.

Trade Literature

you should know about

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Tachometers—Catalog 1120 describes the Frahm vibrating reed tachometer for indicating speeds of 800 to 12,000 r.p.m.—James G. Biddle, 1211-13 Arch St., Philadelphia, Pa.

Oil Circuit Breaker—Circular GEA-62 describes the type FK-32-C oil circuit breaker for 7,500 volts, 1,200 amp., and the type FKR-32-C for 15,000 volts, 600 and 800 amp.—General Electric Co., Schenectady, N. Y.

Inductive Time-Limit Controllers—Publication C-34, third edition, devotes 24 pages to descriptions and numerous illustrations of C-H inductive time-limit controllers in steel mill service.—The Cutler-Hammer Mfg. Co., Milwaukee, Wis.

Gravity Belt Tightener—A circular describes the U.G. automatic belt contactor and other lines of power transmission equipment manufactured by this company.—T. B. Wood's Sons Co., Chambersburg, Pa.

Motor-Driven Pumps and Compressors — Bulletins describe the direct-connected, synchronous motor-driven air compressors and turbine-driven, multi-stage centrifugal pumps.—Pennsylvania Pump & Compressor Co., Easton, Pa.

Leather Belts—A circular gives statements on belt operation from users of Rhoads Tannate and Watershed Tannate belts.—J. E. Rhoads & Sons, 35 N. 6th St., Philadelphia, Pa.

Socket Wrenches — Catalog 326 describes the line of Blackhawk socket wrenches and hand-operated tool grinders.—Blackhawk Mfg. Co., 148 Broadway, Milwaukee, Wis.

Arc Welding—Bulletin 133 describes the lines of Burke variable-voltage and constant-potential arc welders.—Burke Electric Co., Erie, Pa.

Pressure Grease Gun — A circular illustrates and describes the use of Adams grease guns which may be provided with fittings for use with the Alemite, Dot or Zerk systems of high-pressure lubrication.—Adams Grease Gun Corp., 329 Fifth Ave., New York, N. Y.

Resistance Thermometers—Catalog 92 describes the line of Brown resistance thermometers for measuring temperatures from minus 300 deg. F. to plus 1,000 deg. F. and the line of indicating, recording and controlling equipment.—The Brown Instrument Co., Philadelphia, Pa.

Distribution Transformers — Bulletin 2052 describes the Pittsburgh single-phase and polyphase distribution transformers. Bulletin 2053 gives some of the advantages claimed for the Pittsburgh polyphase distribution transformers.—Pittsburgh Transformer Co., Pittsburgh, Pa.

Potheads—Catalog 26 contains 208 pages and illustrates and describes not only the G. & W. equipment but the method of installing this company's line of potheads, underground boxes, distribution specialties, cable terminal devices, insulating compounds and cable splicing material.—G. & W. Electric Specialty Co., 7776-84 Dante Ave., Chicago, Ill.

Panel Boards—Section 4 of Catalog 13 describes a line of panel boards and accessories manufactured by this company.—The Trumbull Electric Mfg. Co., Plainville, Conn.

Conveying Equipment—A folder illustrates and describes the lubricated-gear countershaft box end for Caldwell helicoid and sectional flight screw conveyors.—H. W. Caldwell & Son Co., 1700 S. Western Ave., Chicago, Ill.

Variable-Speed Transmission—Catalog T-66 describes the various sizes and construction of the Reeves variable-speed transmission. A large number of installations are pictured.—Reeves Pulley Co., Columbus, Ind.

Industrial Signals—Visual and audible signals for every industrial purpose are described in the new 16-page booklet entitled, "Benjamin Industrial Signals." Twelve different signaling circuits are shown and numerous other applications described.—The Benjamin Electric Mfg. Co., 120 S. Sangamon St., Chicago, Ill.

Flexible Coupling—Bulletin 103 describes the line of Clark flexible couplings which, it is stated, are fitted together without bolts or screws and do not require oil or grease. It is also stated that they have liberal provision for angular and parallel misalignment and take care of end float.—The Clark Controller Co., 1146 E. 152nd St., Cleveland, Ohio.

Speed Reducers—A catalog describes the complete line of Pittsburgh worm, spur, herringbone and spiral bevel herringbone speed reducers in any ratio for giving straight-line, right-angle, or vertical drives. — Philadelphia Gear Works, Richmond and Tioga Sts., Philadelphia, Pa.

Gears and Speed Reducers—Catalog 200 is a 600-page handbook and contains, in addition to the regular catalog material on gears and IXL speed reducers, a considerable amount of engineering information on this equipment, together with mathematical tables and engineering information on mechanical engineering subjects.—Foote Bros. Gear & Machinery Co., 215 North Curtis St., Chicago, Ill.

Electrical Equipment — Frequently issued, small, pocket-sized catalogs, list and describe the various units of new and rebuilt electrical equipment on hand.—The Fuerst-Friedman Co., 1292 E. 53d St., Cleveland, Ohio.

Conveyors—Catalog 5 of the series entitled, "Wherever Conveying Is Done," is devoted principally to illustrations and descriptions of installations of Brown portable elevators and Standard tiering machines for piling and handling packages.—Standard Conveyor Co., North St. Paul, Minn.

Safeguards—A catalog illustrates and describes a number of safeguards and approved safety equipment for wood and metal-working machinery, belt guards and other safety devices.—The Surty Mfg. Co., Inc., 4127-4139 W. Kinzie St., Chicago, Ill.

Industrial Paint—A circular entitled "More Light" describes the use of Barreled Sunlight in industrial plants. Another circular gives architects' and engineers' specifications for the painting of various interior surfaces with Barreled Sunlight.—U. S. Gutta Percha Paint Co., Providence, R. I.

Choke Coils—Bulletin 117 gives dimensions for both light- and heavy-duty outdoor choke coils. — Electrical Engineers Equipment Co., Chicago, Ill.

Portable Woodworking Machines—Catalog 403 devotes 40 pages to describing and illustrating the line of Wallace portable woodworking machinery for use in maintenance and repair shops, pattern making, cabinet work and other lines.—J. D. Wallace & Co., 134-158 S. California Ave., Chicago, Ill.

Portable Volt-Ammeter — Circular GEA-305 describes the type DS-2 direct-current, portable volt-ammeter which is made in various ranges for general testing purposes.—General Electric Co., Schenectady, N. Y.

Ball-Bearing Pulleys—A circular describes the Pyott ball-bearing loose pulleys.—Pyott Foundry Co., 328 No. Sangamon St., Chicago, Ill.

Oil Circuit Breakers—Special publication 1643-A describes the application of oil circuit breakers, the determination of short-circuit currents, the precautions necessary, and devotes a number of pages to tables and charts.—Westinghouse Electric & Mfg. Co., Pittsburgh, Pa.

Pyrometers—Catalog 15 describes the line of Brown pyrometers for the measurement of high temperatures, illustrates a number of the recording charts used, describes their installation, and gives other valuable information on the use of this equipment.—Brown Instrument Co., Philadelphia, Pa.

Pneumatic Conveying — Bulletin 514 illustrates the use of the Dracco pneumatic conveying system for unloading and conveying soda ash and sand in a large soap manufacturing plant.—The Dust Recovering & Conveying Co., Harvard Ave., and E. 116th St., Cleveland, Ohio.

Time Limit Attachment—Bulletin 530 illustrates and describes the operation of the Roller-Smith direct-acting, time-limit attachment for standard type circuit breakers.—Roller-Smith Co., 233 Broadway, New York, N. Y.

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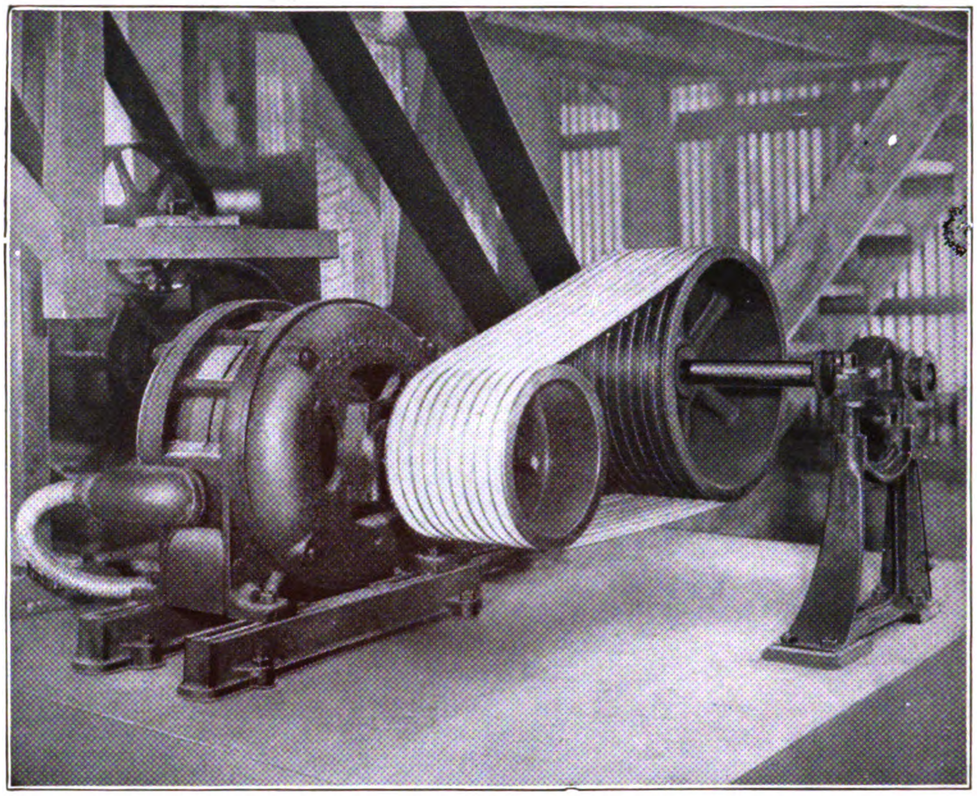

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INDUSTRIAL ENGINEER

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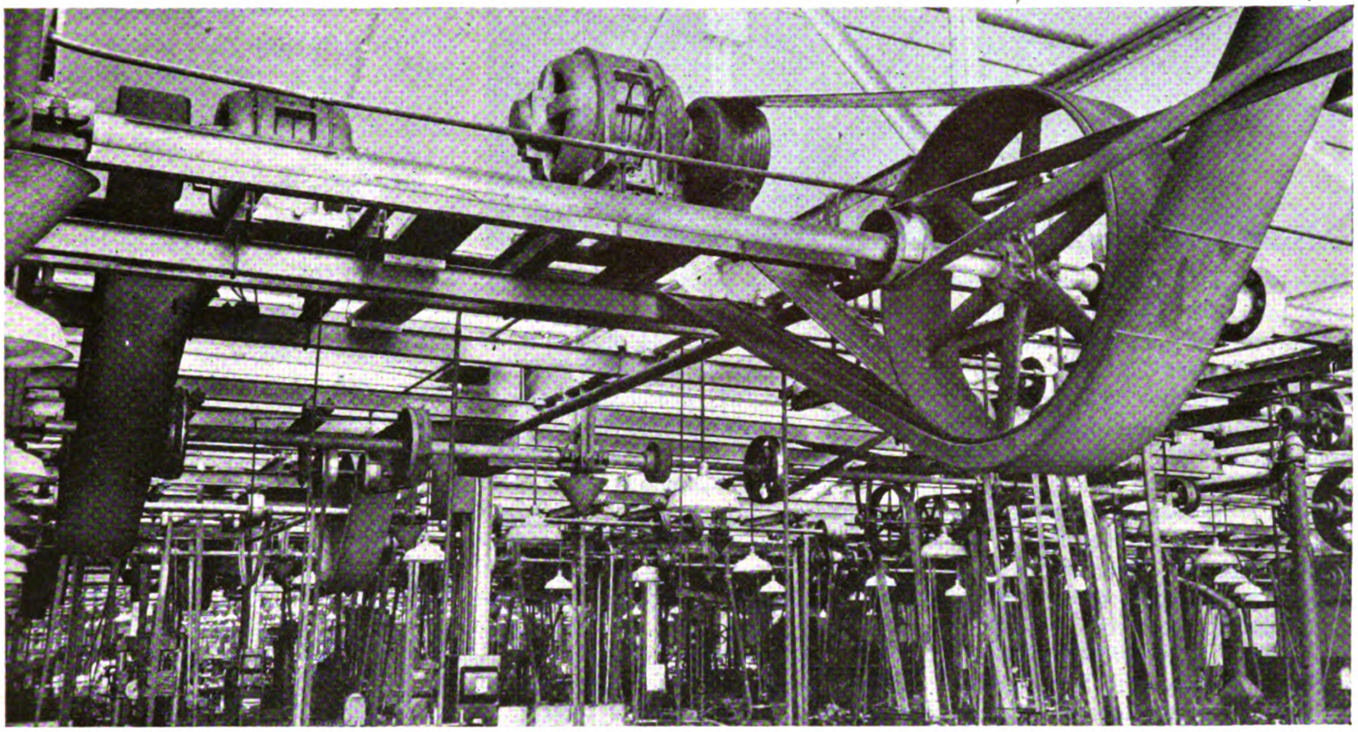


Method of mounting lineshafts and drives is standardized

Maintenance work can be done in less time when the mill-wrighting in the shop is standardized because the workers know from experience exactly how the work can be done easily and quickly and also anticipate the need for any necessary tools or supplies. Whenever a gang has to change a motor or lineshaft they can go prepared for the job and not have to "run back to the shop" several times for something that has been overlooked.

Some results obtained by

Applying a Bonus Plan to Maintenance Work

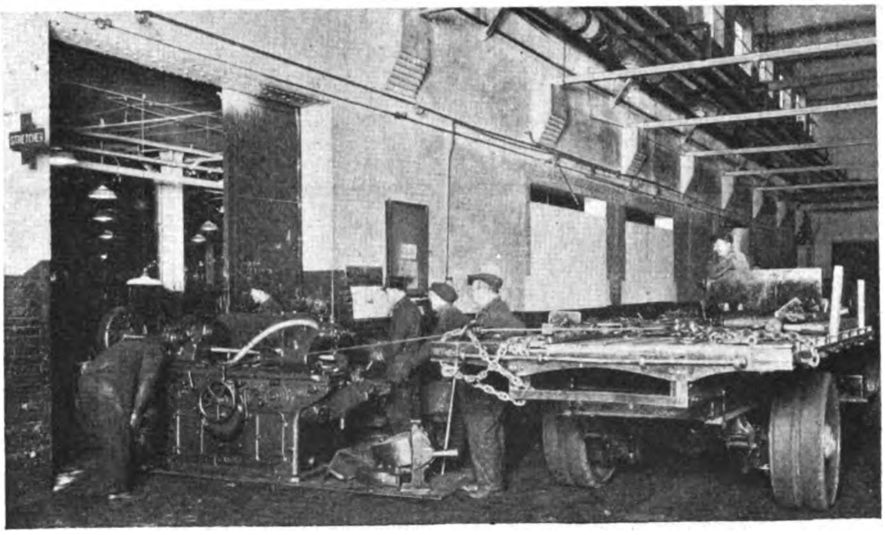
By R. M. HIDEY
Works Manager
and
HENRY HYLKEMA
Plant Engineer, White Motor Company, Cleveland, Ohio

TO BE adequately understood, any discussion of our bonus system as applied to our Maintenance Department must necessarily include certain fundamental facts concerning our bonus as applied to the direct work as a whole.

Our maintenance problems are those of a manufacturing plant as opposed to an assembly plant, as we build all of our engines, axles, and transmissions and do all of the machining of the parts. We make a high-grade product, necessitating exacting work in our manufacturing divisions, which calls for the employment of highly-skilled labor. Our plant extends over an area of 35 acres and has approximately 1,600,000 sq.ft. of floor space, so that our maintenance requirements are of a wide variety.

In 1921, when the various production departments were put on a production bonus plan, it soon became evident that we could further our plans for the application of scientific management principles to our plant, by extending the production bonus plan to include the various units of indirect labor. To fully comprehend this application of our bonus system to our Maintenance Department, however, we must first summarize the features of our bonus system as applied to our direct production departments.

Under our plan, all jobs are classified, so that jobs requiring equal ability and the same degree of skill will be paid equal bonus, regardless of the department in which they happen to be located. For the purpose of computing bonus pay all jobs are divided into ten classes. Bonus Class 1 pays 25 cents for a standard 8-hr. day at 100 per cent efficiency. Continuing in jumps of 25 cents per class per standard 8-hr. day, the bonus increases to $2.50 per standard 8-hr. day for bonus Class 10 for 100 per cent efficiency.



One of the activities of the Yards and Ways Department.

Miscellaneous heavy work, such as moving machinery, can be handled to better advantage if good facilities are provided for doing it. In this case a truck with a winch is being used to pull a machine up the narrow shop aisle on rollers and out into the service bay onto a large sheet of steel which serves as a skid. Small machines are often moved on lift truck platforms. The prospect of a bonus is an incentive to the men to use their initiative to speed up the job.

Bonus is paid only for good pieces which pass inspection. It is paid in addition to, and entirely independent, of hourly wages. We go so far as to pay our bonus in separate envelopes so as to maintain this independence, and to encourage the saving of the bonus money.

The worker begins to earn bonus when his efficiency reaches 60 per cent, and as his efficiency increases, his earnings increase proportionately as far as his skill and energy will permit him to go. Should he work less than the standard 8-hr. day, his bonus is computed on the same basis as for a full day, and he is paid bonus proportionately for the time he works, whether it be one hour or eight.

In studying the question of applying a bonus system to our indirect labor, we naturally considered the fundamental principles underlying our production bonus plan. We began consideration of its application to our Maintenance Department about three years ago, when our cost records began to show that the cost of our Maintenance Department per truck unit did not decrease with increasing truck production. Furthermore, continuous production is dependent on continuous operation of equipment, and we wanted to put the maintenance of production equipment on as firm a foundation as that of production itself. These two facts, coupled with the constant requests of the maintenance men for a bonus system similar to that in the production departments, provided the impetus for our study of the situation.

Our maintenance group is organized under the general supervision of the Plant Engineer, and under the immediate charge of the Master Mechanic. The group includes maintenance proper, steam, air and power equipment, janitors and watchmen, yards and ways, garages, locomotives and cranes, refrigeration, and general.

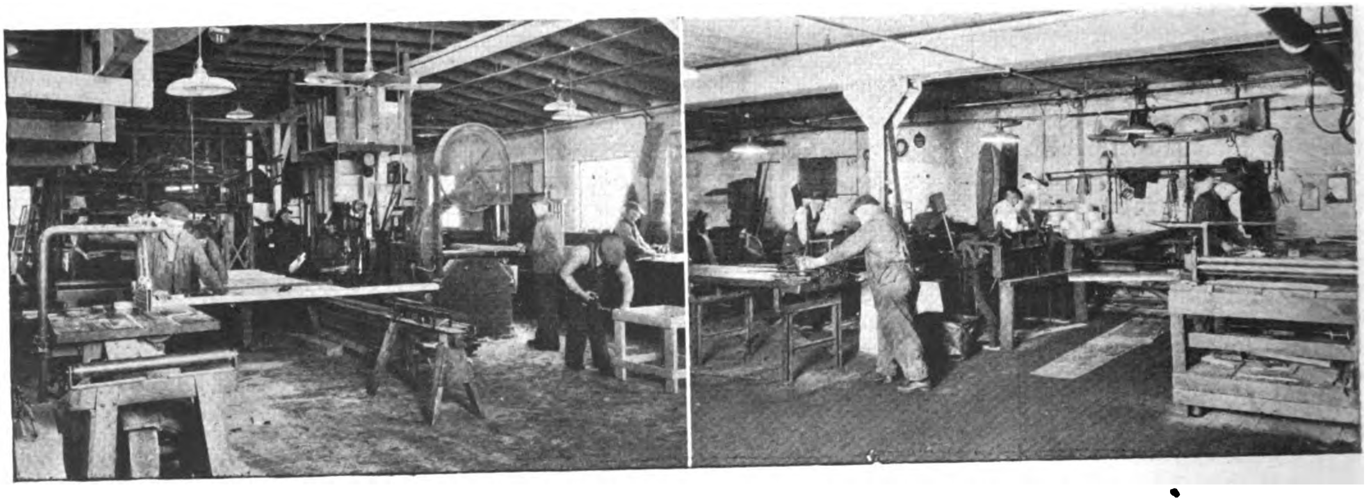
These plant services are usually the ones included in Plant Engineering and are classified as indirect labor; they are seldom considered as coming within that group of activities which can be estimated or predetermined closely enough to place on a time schedule or under a bonus system.

However, we thought that our basic fundamentals were sound and determined to try to develop a bonus plan for the Maintenance Department. We decided that any plan adopted must consider those elements of maintenance work which could be individually time-studied and placed on individual bonus as were all of our production jobs.

This was the first step, and after an analysis had been made of all of the jobs in the Maintenance Department they were classified into two groups: first, those which could be individually time-studied and, second, those which seemed to be applicable to some sort of a group plan.

We then started out to get as close an estimate of the general efficiency of that part of the Maintenance Division as we could under the group plan and then devise a means of measuring this efficiency. We proceeded in about this manner: We assigned, for example, three trained time-study observers to study three plumbers. On alternate days each observer recorded everything which his man did during the day. In this way we obtained three independent observations of each plumber.

The observers reported that on an average the plumbers worked about



Both the carpenter shop (left) and the sheet metal shop (right) are used for maintenance work only.

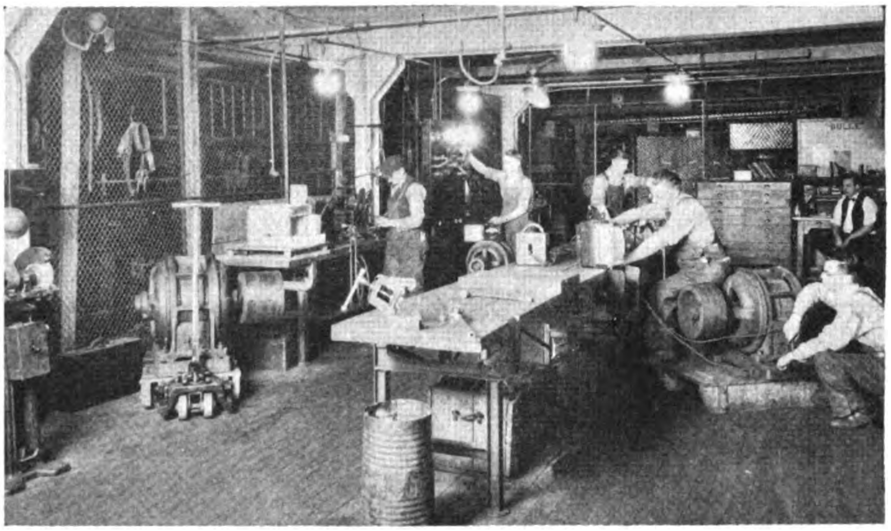
70 per cent of the time. The remaining 30 per cent was spent either in idle time or in unnecessary movement. In other words, we found that our plumbers at the factory were just about the same as those we call to our homes. They went to the job first and looked it over; then returned to their base of operation to get their tools.

In general, investigations in a large number of plants by various authorities who have made a study of wage incentive plans, show that men working without extra wage incentives will have an efficiency of about 50 per cent. The loss of 50 per cent in efficiency is due to unnecessary or unplanned time, or to a poor method of doing the work. For the first two the men themselves are responsible, and for the last case the management is responsible. When we first adopted the bonus system in 1921, we made it a part of our job to see that adequate provision was made to provide the proper equipment to perform the work by the very best methods. We have tried to adhere strictly to this policy.

The procedure for plumbers was followed through for carpenters, electricians and others to whom this method could be reasonably applied. Having determined the relative efficiency of the men in the maintenance group, our next step was to ascertain the maintenance force required for any given volume of production.

The first step was to determine what were the minimum requirements. For this purpose we assumed the plant to be shut down to zero production and boarded up for at least a year. Then by employing our judgment as to the reasonable precautions required for adequately protecting our property under these conditions, we figured out the number of men necessary to keep on our maintenance payroll. Both winter and summer schedules were set up to take care of the difference in the number of men required during winter as compared to those necessary during the summer. The summer schedule begins with the first of May and ends with the last day of September. The winter schedule covers the other months.

Without going through the details of determining the number of watchmen, carpenters, clean-up men, and others necessary to guard the plant and care for the small office force



One end of the electrical repair shop.

Extensive rewinding jobs are practically all sent outside. Motors are handled more easily and quickly by putting them on platforms and moving them with a lift truck. All motors are provided with a pulley which will give the proper reduction to the standardized lineshaft speed anywhere in the shop.

necessary under the conditions outlined, the net results were that we found we would require a force of 40 men in summer and 44 men in winter.

By making use of our records of different maintenance forces employed at various production schedules, we then worked out a curve which gave us the man-hours required for almost any rate of production. This, of course, was with our maintenance men working at 100 per cent efficiency. Correlating all of our information, we obtained the maintenance man-hours applicable to a single truck unit. Adjusting this figure again for gross plant operation, figured at 80 per cent efficiency, we now had a figure which represented the maintenance man-hours required to produce a truck unit.

With the information now available, it was a simple matter to incorporate our findings in a table which represents man-hours at various efficiencies required to maintain various production schedules. This table is the basis for figuring all bonus pay.

It was evident that to obtain the largest saving possible it would be necessary to secure co-ordination and co-operation between all of the men in the maintenance group. The functions and activities of this group are so overlapping that it was not feasible to attempt to make any fine distinctions as to proper division of work. For this reason it was decided to make the group large and include all of the divisions of the Plant Engineer's group in our bonus calculations. This gave not only each group but also each member of each group a definite incentive to co-operate and co-ordinate his work with that of the others. Therefore, on January 1, 1924, we put our maintenance department as a whole on the bonus plan.

A certain few details merit some explanation at this time. The discussion following, or preceding, however, cannot be considered exhaustive. This discussion as it is written is designed to be of general interest. With this in mind, then, certain detailed information essential to putting such a plan into effect has been omitted as not properly belonging to considerations only of general interest.

It is of interest to know, however, that new construction work which does not exceed 10 per cent of the allowance in standard hours for all maintenance work, must be included with this department's regular activities. New construction work exceeding the 10 per cent allowance is handled through contracts with outside concerns.

Bonus for janitors, scrub women, and others whose work can be time-studied by ordinary time study methods, is figured daily. Each person receives an individual bonus slip on which, along with other information, is recorded his efficiency and exact bonus pay for the previous day. Those who are subject only to group performance records, receive their bonus slips weekly. These short bonus periods give the worker a fre-

quent reward which, it has been our experience, goes a long ways toward sustaining interest in the bonus—if such were needed.

Formerly about all our watchmen did was to attend strictly to their duties as watchmen, but since they have been included in the bonus group we have noticed one watchman who secured a broom and now keeps the sidewalks swept for about 100 ft. on each side of his shanty. We waited with interest to see what he would do in winter and, sure enough, he kept the snow shoveled off all during the winter. In this way the man who otherwise would have to keep the walk clean, is left free to put in his time profitably elsewhere.

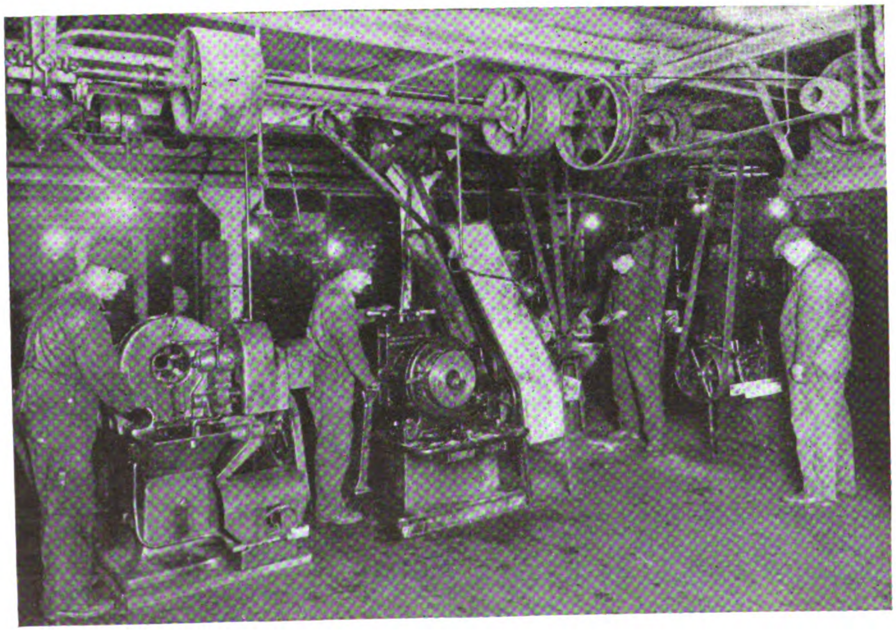
A good example of the manner in which our bonus system has inspired increased efficiency is in the case of our painters. Painting, being an operation which can be time-studied, was placed on bonus on a time-area basis. In establishing this, consideration was given to the different types of work, such as the location, structure and amount of time required to cover and uncover the machinery or floor. Practically all of the painting work is done by the use of an air gun. We paint the interior of our factory on an average of about once in every three years. As our factory buildings are practically all single-story structures, much of the ceiling painting is in saw-tooth roofs. To help the men in their work we have devised an extension arm about 8 ft. long to which the gun is attached and operated by a wire. This enables the painter to spray almost the entire ceiling with a minimum amount of scaffolding or staging. The saving in time which resulted from this was, of course, taken into consideration in determining the standard time for the work.

However, the painters themselves showed ingenuity in devising methods of increasing their efficiency. For example, it had been the practice to stage or climb up into the peak of the saw-tooth and hang a canvas over the windows to prevent the spray settling on the glass. They have now fastened the canvas to a rod like a curtain and push it up into the peak, where it is held in position by uprights cut to the proper length. This protects the windows. Also, it was frequently necessary for the men to cover machines or stock to prevent spray from settling on them. Now, however, they suspend the canvas from the ceiling in much the same manner as is done to protect the windows, thereby increasing their efficiency considerably.

A question which we are frequently asked is, "If the men receive a bonus on the saving of time on a job, what is there to prevent them from rushing it through as quickly as possible, even though they might know that a few minutes saved now will mean more minutes in repairs later?" It has been our policy to retain men in our employ regularly. We take considerable pride in the service records of our employees. The men know or soon find out that it is not the single job which they do that gives them their bonus, but the accumulated savings on many jobs through a long period of time. They expect to be on the job a month or a year from today and so they do not want to risk the chance of losing their bonus at that period through false economy now. Maintenance and service must come first and the bonus will follow naturally.

This view shows a section of the pipe shop at the White Motor Company.

One of the important wastes of time under the former plan was caused by unnecessary trips between the shop and the job. When the men are working under a bonus plan they anticipate their needs and make fewer trips, which gives them much more time for productive work on the job.



When a bonus plan of this sort is in effect, the men object strenuously to hiring extra help unless they see that it is absolutely necessary. This is because the extra man-hours will go into the total hours worked, to compare against the standard hours. This, of course, decreases the departmental efficiency, and so decreases their individual bonus. Thus each man has a definite incentive to do as much work as possible himself, and to keep the number of men in the department down to a minimum. The men soon notice if one of their members does not put in his best efforts. In such a case they do not hesitate to let him know about it, thus taking care of the situation themselves.

The work of the Yards and Ways Department is very hard to schedule. It also varies largely with production and, therefore, has been included in a general plan on the unit production basis. Many novel methods of moving heavy machinery have been inaugurated, one of which is shown in an accompanying illustration.

In the final analysis, before the efficiency of watchmen, maintenance men and others whose efficiency cannot be computed on a time area-basis can be calculated, the efficiency of those whose work can be so measured is computed. Then the standard hours allowed and the actual hours required for the work of janitors, painters, and so on, are subtracted from the respective figures for the whole maintenance group. The remaining figures for standard hours allowed and actual hours required are the basis for computing the efficiency of watchmen, maintenance men and others whose work is dependent on the efficiency of the whole group.

It is apparent that janitors, painters, and so on, have an individual incentive for reaching a high

efficiency, because they are paid according to their individual performance. There is also a definite incentive for watchmen, maintenance men and the others to help them with their work and to help them cut down the number of men, because the efficiency of the former is dependent upon the efficiency of the latter.

A discussion such as this normally inspires two questions: First, is the plan successful and, second, to what is its success attributed? We regard the plan as successful. It has been a distinct benefit to the workmen and has been an aid to the management.

In substantiation of the statement that it appeals to employees, little more need be said than that it provides them increased wages, good working conditions, steady employment, and a chance for individual recognition.

At the time of the first pay period after its installation the efficiency of the group was 67 per cent, from which point it has gradually risen to an average well above 90 per cent. This department itself is somewhat responsible for working conditions, and with the incentive provided for doing their work, naturally these conditions have been very much improved.

Unusually low labor turnover testifies to the steady employment which the system assures. And in the separate envelope in which bonus is paid semi-monthly, each man receives individual recognition of his work during the previous period.

One of the chief features of our bonus system is that the supervising heads of departments and the group heads, as well, receive a bonus pay based directly on their departments' efficiency. Naturally this gives them ample incentive to keep their efficiency as high as possible. Furthermore, before the plan had been long in operation, it developed that foremen and workmen themselves spontaneously developed what we might call "preventive maintenance," for the lack of a better name.

Before the advent of the bonus plan it was not unusual, for example, for repair men to have a number of jobs waiting for their attention. But now these men go out and check up to see how things are running so they can make repairs before breakdowns occur. This spirit of prevention is in evidence throughout the whole department and probably is quite an element in keeping up the efficiency of the men themselves, and of the department.

This attitude has naturally lowered costs, but what is almost equally important from a production standpoint, it has provided more efficient operation of production equipment. The co-operation and co-ordination referred to heretofore, have been important elements in elevating the spirits and morale of the men in the department.

A humorous illustration of this occurred one night during cleaning hours in one of the offices. It seems that one of the scrub women of a group of four was opposed to the bonus plan, and finally succeeded in winning one other to her side. The other two who worked hard to raise their efficiency had to share the rewards with the recalcitrants and finally engaged them in a pitched battle in order to obtain co-operation. Needless to say, when employees compel co-operation among themselves, a plan which fosters such co-operation is of direct benefit to the management.

We regard the successful operation of the plan as being due to the following characteristics:

First, the plan itself is fundamentally sound. It is reasonable in every respect and is based on logical study of all the elements involved in the situation.

Second, it satisfies both workmen and employer. The extension of parallel studies, modified according to the demands of the situation, to our tool room and our material handling division, which is really another story, at least gives an indication of the manner in which the operation of the plan has been received by all concerned.

The third, and by far the most important, reason why our plan has been successful, is one for the lack of which most unscientific plans have been unsuccessful. Every bonus chart which we issue carries this guarantee: "These bonus prices will not be lowered no matter how long the job may run with this equipment and by the method and design specified in the instruction referred to in the foregoing."

This guarantee never has been and never will be violated. It is the basis for the success of the whole system. Our men believe in it and in us. And when there is that relationship between employer and employee, success should come to both.

Proper Method of Lubricating Wire Rope

PRACTICALLY all the cores of good brands of wire rope, both the preformed and non-preformed types are thoroughly impregnated with a commercial, chemically-neutral rope oil. Although the core retains a liberal supply of this lubricant which gradually oozes out as the rope is used, frequent application of a good lubricant during service is necessary to prevent the core from becoming dry.

A wire rope having a dry core will both wear and crush quicker or will absorb moisture with the result that the core will deteriorate rapidly and the inner wires will corrode, with shortened rope service as the result.

The smaller the sheaves or the heavier the tension on the rope, the more often should the rope be lubricated so as to prevent too rapid wearing of the core in the first case, and excessive crushing in the latter case.

A good lubricant retards corrosion of the wires and deterioration of the core, reduces internal friction which is a cause of wires breaking from increased bending stresses, and decreases external wear. The lubricant should be thin enough to penetrate the strands and the core but not so thin as to run off the rope, nor so thick that it merely covers the rope.

Therefore, a thicker semi-plastic compound applied *hot* in a thinned condition is best to use wherever possible. It will penetrate while hot and then cool to a plastic filler, excluding the entrance of water, and both preserving and lubricating the inner wires and cores of the steel cable.

To properly lubricate with a heated lubricant, it is necessary to have the rope run slowly through the heated tank of oil so that proper penetration takes place. Where this is not possiple, an application of a thinner, unheated lubricant will give better practical results than many other methods now used for rope lubrication.

The American Cable Co. strongly advocates the practice of lubricating the rope just after installation and before running in service, particularly when such ropes have been kept in storage for some time as spares for mine, dredge or other outdoor work where service conditions are severe.

Here is an instance where the light-colored walls help to conserve the light. Even with this direct-illumination system, the white ceiling reflects some of the light. The reflecting value of the ceiling is very important when daylight is available.

What it pays to know about

Lighting Value of Paint in Industrial Plants

including a discussion of the reflection factor and other properties which affect its value, with pointers that will aid in using it most effectively

By M. LUCKIESH
and
E. W. COMMERY

Lighting Research Laboratory, National Lamp Works of General Electric Co., Nela Park, Cleveland, Ohio

WHEN we compute the amount of light lost through neglect in painting surfaces or in maintaining them at high reflection factors we find the result to be staggering. In addition, there are many other reasons for giving proper attention to the painting of walls and ceilings.

Light surroundings are helpful in reducing glare. A light source which is glaring when viewed against a dark background may be rendered satisfactory when viewed against a bright background. The impression of bad lighting has often been created by approved lighting equipment when used with dark surroundings, even though adequate intensities of illumination were delivered to the working plane. Light surroundings are cheerful and stimulating. Disorderliness and dirtiness are far less prevalent amid light surroundings. Both natural and artificial lighting are aided if the interiors of buildings, and the objects therein, are light in color.

The amount of light reflected from a surface is dependent on the color of the surface. If it is dark or dirty the amount of light reflected may be only a few per cent, whereas the best white paints reflect from 80 to 85 per cent of the light incident upon them. The illumination intensities generally found in the interiors of our work places are far below those which are economically practicable. For this reason alone every possible means should be utilized to conserve the light generated by the lighting system.

Paints exhibit the same reflecting characteristics that surfaces do in general. Regular or specular reflection is that of a perfect mirror where the angle of reflection equals the angle of incidence of the rays of light. This condition is approached by polished metals and the surface of glossy varnish. A thick, smooth coating of glossy varnish on a jet black surface is a very good mirror. Such surfaces are undesirable from the viewpoint of lighting because they reflect images of the light sources, thereby causing glare and other attendant effects, such as visual discomfort, eye strain and reduced visibility. Glossy desk tops, glossy walls and ceilings, and various polished surfaces are possible sources of glare.

Paints with a dull finish closely approach perfect diffuse reflection,

although semi-matte finishes reflect not only diffusely but superimposed on this is a sort of regular reflection. A painted surface coated with glossy varnish, or an enameled surface, also exhibits a combination of diffuse and regular reflection.

The measurement of reflection factor (ratio of total reflected to total incident light) is now a comparatively simple matter in a properly equipped laboratory, but accurate results can be obtained only with a proper instrument. Usually a color difference is involved and results obtained outside the laboratory are far from accurate. Furthermore, the reflection factor of a surface depends upon the direction and distribution of the incident light in all cases excepting that of a perfectly diffusing surface.

In general, walls and ceiling play a part in the distribution and quantity of light to the work plane, but the part they play depends not only upon their reflection factor, but also upon the character of the lighting system. In other words, the walls and ceiling can influence the lighting only insofar as they have an opportunity; this is a matter of the percentage of the total light which is incident upon them. In addition, there are many objects in the interiors of our buildings which absorb light, and even the best white walls and ceilings usually do not reflect more than 80 per cent of the incident light. It is impracticable to attempt to keep the floors highly reflecting and, furthermore, white surroundings do not by any means present the most desirable conditions from the viewpoint of eye comfort and the best vision. When considered from all angles, it is questionable whether the walls directly in the field of view should have a reflection factor greater than 50 per cent.

In the case of direct lighting with opaque, white enameled or silvered glass reflectors, little light reaches the ceiling directly; so its reflection factor when artificial lighting is employed is of little importance, although it is of great importance in the utilization of day light coming through the windows. In the case of indirect lighting and so-called semi-indirect lighting, a large percentage of the light is emitted upward toward the ceiling and, therefore, the reflection factor is important. Walls are important from the standpoint of reflection factor, in proportion to the percentage of light that impinges upon them. Obviously, in large rooms they are of much less importance than in small rooms. They are generally of much greater importance in natural lighting from windows, than when artificial lighting is employed.

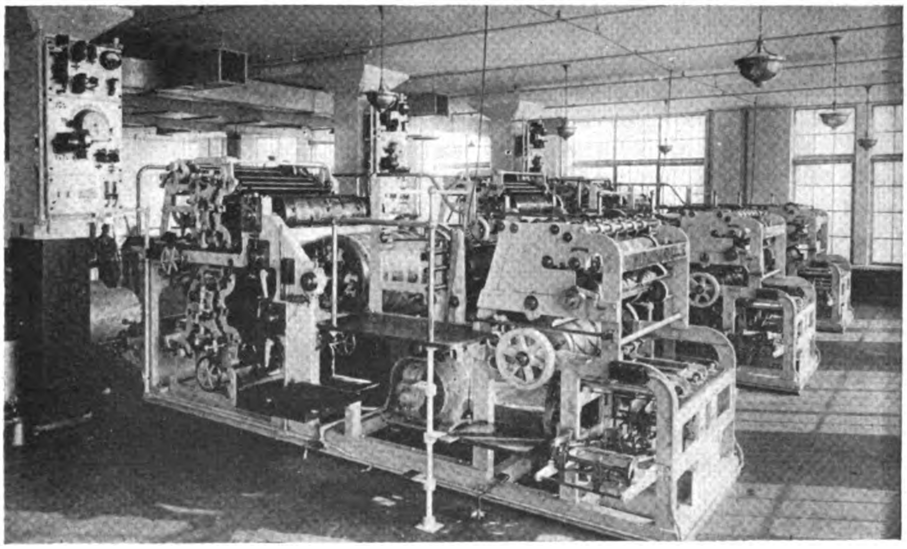
The influence of the reflection factors of ceilings and walls in artificial light is shown in the accompanying table, for three different types of lighting systems and for three sizes of rooms. The lighting equipment is assumed to be hung 10 ft. above the horizontal work plane upon which the relative values of illumination from a certain number of lamps are shown in the table. These data were deduced from the work of E. A. Anderson[1] on utilization factors. The numbers following the words "ceiling" and "walls" are the respective reflection factors. The direct lighting system is one in which approved white enameled or silverized glass reflectors are used. The second system employs approved, enclosed, diffusing-glass equipment. The indirect system is one in which approved, silvered glass or very dense opal glass bowls are used.

The data in the table will bear considerable study. In the large rooms the walls play an important part and it is interesting to note in item (*A*), for example, the effect of the walls as the room size diminishes. This feature is conspicuous in all the items. The ceiling plays a small part in the case of direct lighting with opaque reflectors. This is seen by comparing item (*B*) with item (*D*) where the walls have the same reflection factors, but those of the ceiling are 70 and 30 per cent respectively.

Enclosed, diffusing-glass equipment emits a large amount of light upward to the ceiling and outward to the walls. This is quite evident by the generally lower values of relative illumination under this system than under the direct lighting system. Both the ceiling and the walls influence the relative foot-candle values on the work plane. By comparing (*F*), (*G*), and (*H*), the influence of the reflection factor of the wall is seen. By comparing (*G*) and (*I*), or (*H*) and (*J*), the influence of the reflection factor of the ceiling is seen. There are several outstanding features in this table, of which the following may be mentioned: (1) The appreciable influence of walls of small rooms or narrow rooms in which direct lighting opaque reflectors are used. (2) The great influence of both walls and ceiling in all of the rooms, but particularly those of small and intermediate sizes in the case of lighting systems that employ enclosing, diffusing-glass equipment. (3) The very great influence of walls, and particularly ceilings, in the case of indirect lighting systems; that is, in systems in which most or all of the light is emitted upward by the lighting equipment. These various items present adequate proof of the lighting value of paint.

Manufacturers of machinery have persisted in painting machines and other equipment either black or a very dark color. This practice not only contributes to the cheerlessness of poorly illuminated factories, but

[1] Illumination Design Data, E. A. Anderson, Bulletin 41 National Lamp Works of General Electric Co., Jan. 15, 1921.



In this case painting complicated machines white is an aid in making adjustments and brightens up the room.

even in the modern factory where the lighting is fairly well done, dark machines have a depressing effect and often render the lighting of important areas on the machines exceedingly difficult. The faceplate of a lathe, certain areas of milling machines and particularly complicated machinery such as printing presses can be painted a washable white or light gray and by reflection much light can be thrown on the work, and particularly in the shadows. All machines and equipment should not be painted white. Such a condition would be insufferable. However, if the equipment were painted a very subdued color having a reflection factor of 20 to 25 per cent, much light would be saved by reflection.

The use of glossy paints for interior walls and ceilings is probably due to the belief that flat paints accumulate and retain more dirt than do gloss surfaces. Tests conducted by H. G. Lima[3] indicate that in a dry interior, in which there was a slow accumulation of dirt, slight differences existed at first between the gloss and flat paints. Continuing the exposure a very slight, and later a very decided contrast, was found. In every case the gloss paint had accumulated more dirt than had the flat paint. Further tests conducted in interiors in which moisture was present, and also on samples tested out-of-doors on the roof, again showed that the gloss paints became dirtier than the flat paints. These results, coupled with the advantages that accrue from a lighting standpoint, surely justify the use of flat interior finishes.

Furthermore, the specular or regular reflection from glossy paints, and more particularly enamels, has led many to believe that these finishes reflect a greater amount of light than do the flat finishes. The amount of light which a glossy varnished surface reflects is independent of the diffuse reflection of the coating beneath this transparent coating. The specular or regular component of the reflected light due to the glossy surface amounts to about 4 per cent when the light strikes the surface perpendicularly. This, however, is generally not an additional 4 per cent over the diffuse reflected light from the coating under the gloss, because most of the vehicles used in producing the gloss are colored slightly yellowish. This colored vehicle surrounding the particles of pigment results in a lowered reflection factor of the pigment and generally the net result is a slightly lower reflection factor for glossy finishes than for flat finishes which have been made up with any given pigment.

[3]Technical Bulletin No. 5, 1924, Pittsburgh Plate Glass Co.

Influence of Reflection Factor on Foot-Candles Obtained Under Various Conditions

Lighting System and Reflection Factors of Ceiling and Walls	Relative Foot-Candles on Work-Plane: Small Room (10 ft. by 30 ft.)	Medium-Sized Room (20 ft. by 50 ft.)	Large Room (100 ft. by 100 ft.)
Direct Lighting System:			
(*A*) Ceiling 70; walls 50	50	90	100
(*B*) Ceiling 70; walls 30	42	86	97
(*C*) Ceiling 70; walls 10	35	81	94
(*D*) Ceiling 30; walls 30	40	84	94
(*E*) Ceiling 30; walls 10	35	81	91
Enclosed Diffusing Glass:			
(*F*) Ceiling 70; walls 50	32	67	80
(*G*) Ceiling 70; walls 30	25	59	74
(*H*) Ceiling 70; walls 10	20	54	68
(*I*) Ceiling 30; walls 30	20	49	58
(*J*) Ceiling 30; walls 10	17	45	55
Indirect Lighting System:			
(*K*) Ceiling 70, walls 50	23	52	65
(*L*) Ceiling 70; walls 30	19	46	60
(*M*) Ceiling 70; walls 10	16	42	55
(*N*) Ceiling 30, walls 30	10	25	32
(*O*) Ceiling 30, walls 10	9	23	29

Inasmuch as white paints play such an important part in the effectiveness of many lighting systems, their specific consideration is of particular value. From a practical viewpoint, reflection factor (both initial and sustained), hiding power, specific gravity, cost, and character of surface are important factors in the choice of the paint to be used.

In recent years many paint manufacturers, realizing the value of highly reflecting paints, have shown marked improvements in their product. Today a number of white paints are available having initial reflection factors of 80 per cent or better. In general, white paints have shown a decreasing reflection factor with age, due to discoloration, but even this characteristic has been improved with certain combinations. White paints having high initial reflection factors vary in their behavior with age, some showing only a moderate loss of reflection factor due to discoloration, while others fall off to values equal to those found with paints having considerably lower initial reflection factors. From this it is seen that the average reflection factor over a given period of time is more important than the initial reflection factor.

While it is obvious that paints having a high reflection factor are desirable for the conservation of light, it can also be shown that a definite waste of money occurs when they are not used. For example, in a drafting room that measures 100 ft. by 20 ft. and is equipped with 20, 300-watt, totally-indirect, silvered glass or very dense opal glass bowls, 16 foot-candles of illumination can be provided on the work plane if the reflection factors of the ceiling and walls are 80 and 40 per cent respectively. With electrical energy at $0.05 per kilowatt-hour the 16 foot-candles are obtained throughout the working plane at a cost of $0.30 per hour. If paint having a reflection factor of 70 per cent, instead of 80 per cent, had been used, we find that only 14 foot-candles are delivered to the working plane; still the full $0.30 per hour is being spent for the electrical energy consumed by the lighting system. This represents a monetary loss equivalent to $0.037 for every hour that the lighting system is in operation.

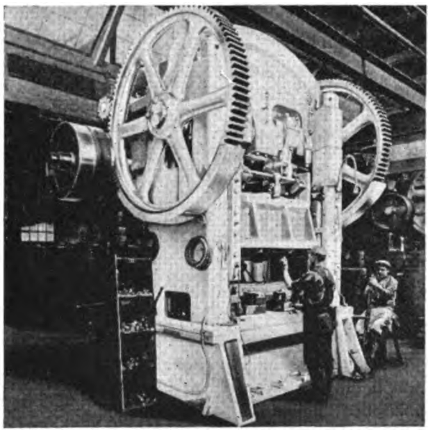
This monetary loss may not seem very significant, but further examination indicates that at the end of 2,400 hr. use of the lighting system, it is equivalent to $90, or the cost of painting the ceiling, assuming that the paint maintained its reflection factor of 70 per cent and no accumulation of dirt had taken place. When lower reflection factors of the ceiling obtain, correspondingly shorter periods of operation of the lighting system effect monetary losses equivalent to the cost of an entire repainting of the ceiling. In fact, this lighting system need be operated only for

810 hr., or nine months, to effect a monetary loss equivalent to the cost of repainting the ceiling, if the reflection factor is 50 per cent throughout that time.

Enclosed, diffusing-glass units are far less dependent on the reflection factor of the ceiling than is the totally indirect system. However, the monetary loss due to light paid for and not received with this type of system in the afore-mentioned interior amounts to the cost of a painting job in approximately 2,700 hr. use of the system if the ceiling reflection factor is 50 per cent. The best reflecting paints may cost appreciably more than the usual paints; however the preceding analysis reveals that the additional expenditure is warranted and will be repaid within a comparatively short time.

Assuming, as a practical standard, the use of a paint having an 80 per cent reflection factor on the ceiling of the above drafting room, which is equipped with a totally-indirect lighting system, any values less than 80 per cent, due to dirt or discoloration, produce a condition of light paid for but not received. This loss, when compared to the cost of repainting, indicates that painting should be done after a period which can be determined easily and more or less definitely.

For a particular installation the solution of the problem involves a number of factors which are generally available. By way of illustration the previously described installation can be used. In this case the most economical period between paintings is approximately 14 mo.

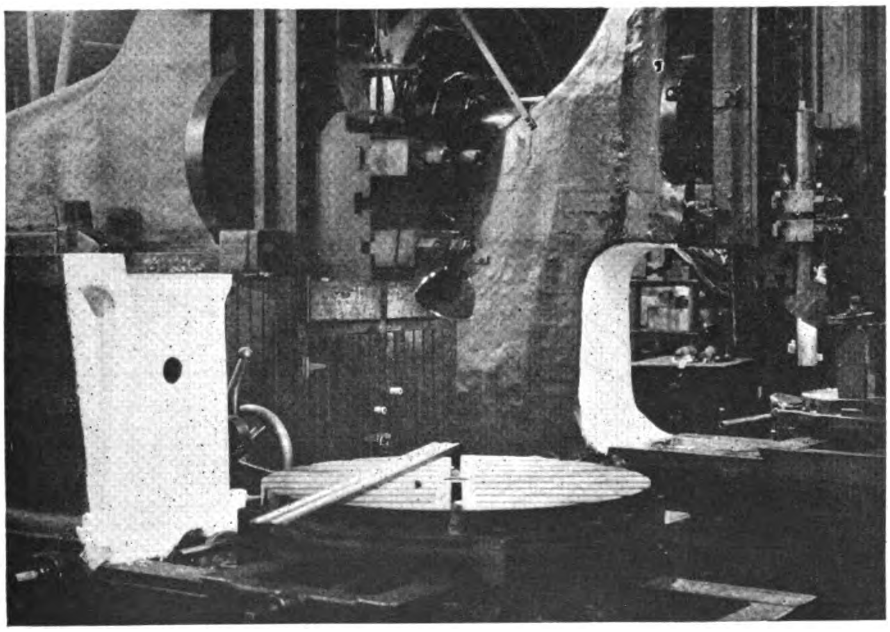


The obstruction to lighting caused by large machines may be greatly reduced by painting them light gray.

The assumptions made in the solution of the problem are as follows:

(1) Initial reflection factor of ceiling and walls is 80 and 40 per cent, respectively.
(2) Location is in an industrial or manufacturing section.
(3) There is a uniform rate of depreciation of ceiling reflection factor of 1.5 points per month; that is, from 80 to 78.5 per cent during the first month, from 78.5 to 77 per cent during the second month, and so on.
(4) There is no depreciation of wall reflection factor.
(5) Lighting system is used 1,000 hr. per year.
(6) Painting of one heavy coat at $0.40 per square yard, or a total of $90 for the entire ceiling.
(7) Cost of electrical energy is $0.05 per kilowatt-hour.

The application of white paint to certain areas of large machines will help to throw more light onto the work and eliminate shadows.



The time interval between paintings is conservative, as the effect of the walls has not been considered and 1,000 hr. use per year is exceeded by many establishments. Furthermore, no consideration of the visual conditions has been taken into account. During the 14 mo. between paintings the illumination intensity will have decreased from 16 foot-candles to 11 foot-candles. The quickness and accuracy of vision and other visual functions are appreciably different under these intensities. For high-contrast conditions, such as black on white (80 per cent reflection factor), increases in these various visual functions ranging from 4 to 18 per cent have been found when the illumination intensities were raised from 11 to 16 foot-candles. While this factor is difficult to evaluate in terms of production for all industries, still it is of such magnitude as to warrant the attention of all of those who are responsible for production.

The relation between production and intensity of illumination has been carefully studied in industrial plants covering a wide variety of operations, and some of the results obtained were reported in an article by Roy A. Palmer, in the August, 1925, issue of INDUSTRIAL ENGINEER. One of these very interesting tests was conducted at the Timken Roller Bearing Co. plant at Columbus, Ohio. This test, which was conducted in the Inspection Department, extended over several weeks, the high and low levels of illumination being alternated weekly. Inspection work requires fairly close visual application, and the effect of the lighting intensity was shown in a striking manner by the production figures under the low and high levels of illumination. When a high level of illumination was provided, production increased; when the illumination was cut down, production decreased. With each change in the level of illumination the production output obtained responded accordingly.

The intensity in this plant was originally five foot-candles, which is not so low as is found in many plants. The new lighting system installed for the test provided 20 foot-candles. While the five foot-candles of illumination were sufficient for fairly good vision, the new installation helped the speed of vision and produced a stimulating atmosphere in the plant so that production was increased 12.5 per cent.

Raising Power Factor

Without the Use of Corrective Equipment

By JAMES B. HOLSTON

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IN THE preceding article, in the July issue, power factor was considered from the standpoints of what it is, the effects of low power factor and why it is undesirable, and the methods of measuring it. When it is known, or has been determined, that the power factor of an industrial plant is lower than is desired, the next step is to select the best means of raising it.

Low power factor is caused largely by the operation of certain types of electrical equipment at low load factors, Induction motors usually constitute the bulk of an industrial plant load and as the "reactive" or out-of-phase" component of the power in ordinary induction motors is practically the same at no load as at full load, it follows that the reading of the "reactive meter" will be substantially independent of the load on the equipment.

The importance of proper loading of motors is strikingly shown in Fig. 1, which gives the average power factor of squirrel-cage motors, ranging from 1 hp. to 100 hp. in rating, when operated at different percentages of full load. Referring to the curve for the 10-hp. motor, it will be seen that the power factor at 50 per cent load is 61 per cent, and at 75 per cent load it is 74 per cent. Comparatively few applications impose an average load of over 60 per cent of the rating of the motor; hence the effective power factor of the unit will be about 68 per cent.

Many motors are used on machines which operate only intermittently during the day, such as grinders, shears, drill presses and similar equipment. The common belief that the power cost of operating the motors running idle is so small that it may be overlooked, and that such motors need not be shut down when the machines which they drive are not in use, takes no account of power factor effect. As has been stated, the "reactive" meter records practically the same with no load on the motor as at full load; therefore, motors idling on the lines produce as bad an effect on plant power factor as do fully loaded motors. For this reason idle operation of motors should be carefully avoided.

Reference to Fig. 2 brings out the interesting and important fact that the efficiency, as well as the power factor of squirrel-cage motors drops off sharply at loads less than 50 per cent.

Due to the inherent characteristics of squirrel-cage induction motors, slow-speed or low-horsepower motors have low power factor and low efficiency, while high-speed or large-horsepower motors have high power factor and high efficiency. This fact should be kept in mind when making any rearrangement of motors for power factor correction, or if any new motors are to be installed.

In both Figs. 1 and 2 the performance of 860-r.p.m. motors has been shown, as this speed is widely used. Higher speed motors of the equivalent horsepower ratings will have efficiencies and power factors slightly above those shown.

The foregoing discussion may serve to explain the somewhat paradoxical title of this paper. One solution of the power factor problem clearly lies in eliminating as far as possible those motors that are operating at low power factor. The simplest and most accurate method of locating the improperly loaded units is to make load tests of the input to every motor which operates for any appreciable period of time. Of course, such motors as may be used only very intermittently on cranes, elevators, blowers, fire pumps and similar drives need not be considered, as they have little or no effect on the power factor of a plant.

LOW POWER FACTOR in an industrial plant may be the cause of a number of conditions that are undesirable from an operating standpoint. It may also increase the cost of electrical energy through penalties imposed by the power company. In this article Mr. Holston describes some practical ways in which power factor can be raised to the point where it ceases to be troublesome, without the use of special, corrective equipment. The use of such equipment will be considered in a subsequent article to appear in an early issue.

Details of the procedure and equipment used in making a load survey of this character were given in an article by H. E. Stafford, on page 310 of the July, 1925, issue of INDUSTRIAL ENGINEER. It need only be said here that three meters are required to make these tests: a voltmeter, an ammeter and a wattmeter, together with suitable current transformers. If graphic or recording-type meters are available they should

Figs. 1 and 2—These curves show the approximate average power factor and efficiency of 220-volt, three-phase, 60-cycle, 860-r.p.m. squirrel-cage induction motors when operated at different percentages of full-load rating.

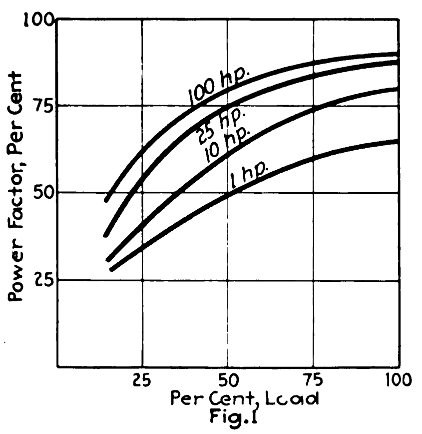


Fig. 1

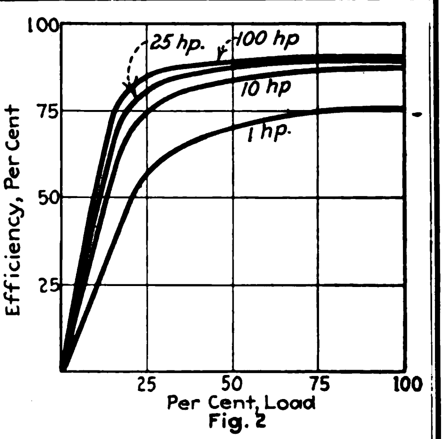


Fig. 2

be used, as a permanent record can then be kept, but indicating meters are perfectly satisfactory. These instruments should be mounted on a small truck to facilitate moving them from one location to another. (An ingenious engineer in one industrial plant used a boys' coaster wagon which served the purpose admirably.) Leads soldered to each end of a blown cartridge fuse will be found convenient in making connections to the ammeter and wattmeter, and spring clips on the voltmeter leads will help to simplify the job of connecting up.

The data obtained are best recorded in some such form as shown in Fig. 3 for study after the tests have been completed. Only three readings are taken—volts, amperes and kilowatts—the other values being obtained from the manufacturers of the motors, or calculated from the performance data. If a polyphase wattmeter is used the reading of the meter will be the full input, but if two single-phase meters are used the readings must be added together to obtain the true input. Voltage and current readings may be omitted if desired, as they are not used in the calculations to be made, but should be taken if convenient in order to determine whether the voltage is low or the current drawn by any motor is excessive.

Fig. 3—Here is a convenient method of recording test data on motors to determine whether they are properly loaded.

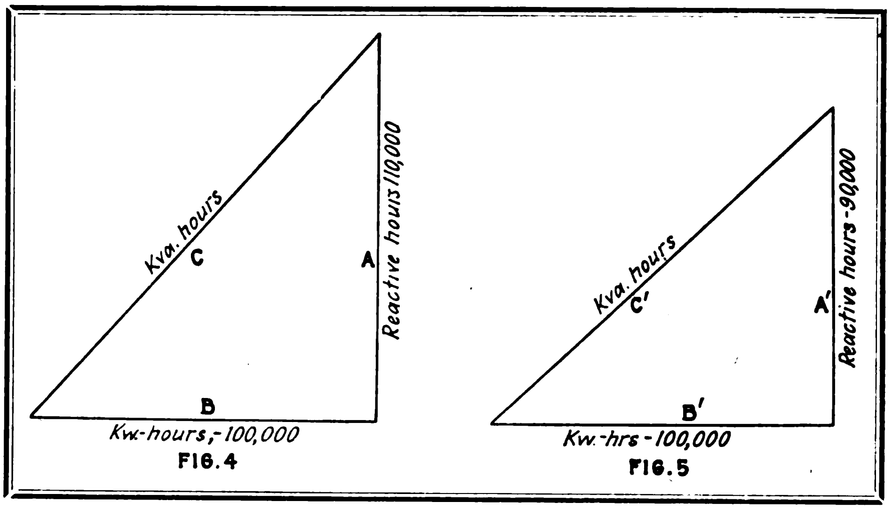
It is advisable to take three readings—kilowatts, volts and amperes—although the latter two may be omitted if desired. After the data have been recorded and corrected, as shown, the per cent of full-load rating may be found by dividing the observed kilowatt input by the kilowatts taken at full load, as given by the manufacturer.

Motor Test Record									
Column (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Drive	Hp.	Test Data			Corrected Data		Mfrs. Data		Per Cent Load *
		Volts	Amps	Kw.	Amps	Kw.	Amps	Kw.	(Col. 7 ÷
			(x 10)	(x 2)	(Using Mult.)		(Full Load)		Col. 9)
Blower No. 1	25	228	4.90	7.7	49	15.4	60	21.1	73.0
Blower No. 2	15	228	3.20	5.5	32	11.0	36	12.7	86.5
Machine Shop Line Shaft	20	227	5.70	9.6	57	19.2	50	16.9	114.0
Air Compressor Pumping	100	227	4.67x50	39.5	235	79.0	242	82.9	95.3
Idle		230	24x50	18.7	120	37.4			45.0
Motor Generator Set	35	230	5.6	8.6	56	17.2	84	29.4	58.5
Circulating Pump	5	230	12.5	2.0	12.5	4.0	13.9	4.5	89.0
Line Shaft 2nd Foor	25	227	4.5	6.85	45.0	13.7	63	21.1	65.0
3rd. Floor	40	227	7.3	11.8	73.0	23.6	96	33.6	70.0

* Efficiency at loads between 50 and 100 per cent assumed to be the same. See Fig. 2

Referring to Fig. 3, a careful study of the results of these tests, which were made in a large industrial plant, showed that several motors were not properly loaded. For example, blower No. 1 required only about 18 hp. to drive it, while the motor was rated at 25 hp. On the other hand, the machine shop motor was overloaded. By adjusting the pulley sizes these motors were interchanged and a better load on each was the result, with a saving in "reactive" power, as the machine shop motor runs only 7 hr. a day, while the blower runs 24 hr. The motor on blower No. 2 was fairly well loaded.

A check upon the load cycle of the air compressor showed that it was in operation only about one-half of the time. An automatic control to cut off the motor when the air pressure reaches 100 lb. and cut it in when the pressure drops to 80 lb., was installed, and saves a substantial amount of useful as well as reactive power.



Figs. 4 and 5—Relation between kilowatt and reactive hours, before and after rearranging motors in a plant to obtain better loading.

Fig. 4 represents the original condition; power factor ($B \div C$) was 67.3 per cent. From Fig. 5, it will be seen that the reactive hours have been reduced to 90,000, which gives a power factor ($B^1 \div C^1$) of 74.3 per cent.

The motor-generator set never drew over 20 hp.; hence a new 20-hp. motor was installed and the 35-hp. motor kept as a spare.

Some other changes were made in operating schedules to give more uniform loading of motors, with resulting savings both in "real" and "reactive" power.

This plant used 100,000 kilowatt-hours per month before the above changes were made and with normal operation registered 110,000 "reactive" hours. Referring to the familiar power factor triangle, shown in Fig. 4, it will be seen that power factor can be determined from these two readings by the use of simple mathematics. As was explained in the preceding article, power factor being defined as the ratio of real to apparent power, it is represented in Fig. 4 by $B \div C$. Knowing the values of A and B, C may be found by taking the square root of the sum of the squares of A and B, which may be expressed as follows:

$$C = \sqrt{A^2 + B^2}$$

In this case A equals 110,000 and B equals 100,000; hence

$$C = \sqrt{(11^2 + 10^2) \times 10^8}$$
$$= \sqrt{221} \times 10{,}000 = 148{,}600$$

Therefore, Power Factor $= B \div C = 100{,}000 \div 148{,}600 = 67.3$ per cent.

By rearranging motors to load them more fully, shutting down idle motors whenever possible, and by working out more uniform operating schedules for motors that were running continuously, this plant was able to decrease the "reactive" hours from 110,000 to 90,000. Referring to Fig. 5 it will be seen that the following conditions then existed:

Power Factor $= B^1 \div C^1 =$

$100{,}000 \div \sqrt{(9^2 + 10^2)10^8} =$

$100{,}000 \div 134{,}500 = 74.3$ per cent

The curve shown in Fig. 6 (tangent-cosine curve) affords a short cut in computing power factor from the readings of the kilowatt-hour and "reactive" meters. In the example shown in Fig. 4 the ratio of "reactive" hours to kilowatt-hours is 1.10. Locating on the curve the point of intersection of the vertical line corresponding to 1.10 on the abscissa or horizontal line in Fig. 6, the power factor is found to be 67.3 per cent, which checks with the previous calculations. In the case of Fig. 5 the ratio is 0.90 and the power factor is found to be 74.3 per cent. This chart is very convenient in making calculations of this kind and has been reproduced of sufficiently large size to be accurate enough for all ordinary calculations.

After the changes mentioned above had been made the kilowatt-hour consumption decreased, due to more efficient operation. For simplicity in calculations this fact was not taken into account in the data shown in Fig. 5. However, annealing furnaces of 100-kw. capacity were added, operating 200 hr. per month and thus using 20,000 kw.-hr. As the power factor of this type of equipment is 100 per cent the over-all plant power factor was raised, as shown in Fig. 7. Inasmuch as the "reactive" meter continues to record the motor load, but gets no additional reactive hours from the furnaces, it will still read 90,000. The kilowatt-hour meter, however, now records the former load plus the 20,000 kilowatt-hours added by the electric furnace, or 120,000. Using Fig. 6, the ratio of 90,000 to 120,000 is seen to be 0.75, giving a power factor of 80 per cent.

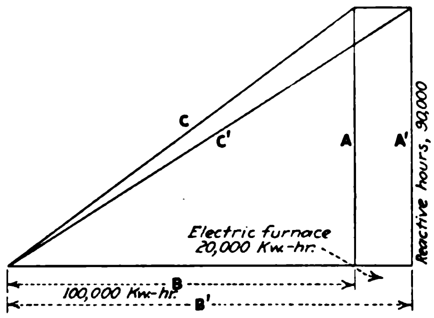


Fig. 7—An electric furnace load will help to raise the power factor of a plant.

After the power factor had been raised to 74.3 per cent, by rearranging motors, the conditions were as represented by the triangle whose sides are shown as *ABC*. The addition of some electrically-heated annealing furnaces increased the energy consumption of the plant 20,000 kw.-hr. a month and created the conditions shown by the triangle whose sides are A^1 B^1 C^1. Then the power factor is represented by $B^1 \div C^1$ which corresponds to 80 per cent.

Incandescent electric lights and resistance heating equipment of all kinds are unity power factor loads and play an important part in the determination of "effective" monthly power factor. If the addition of either is being considered the effect on the plant power factor, especially if there is a power factor rate, should be taken into account before efforts are made to raise the power factor.

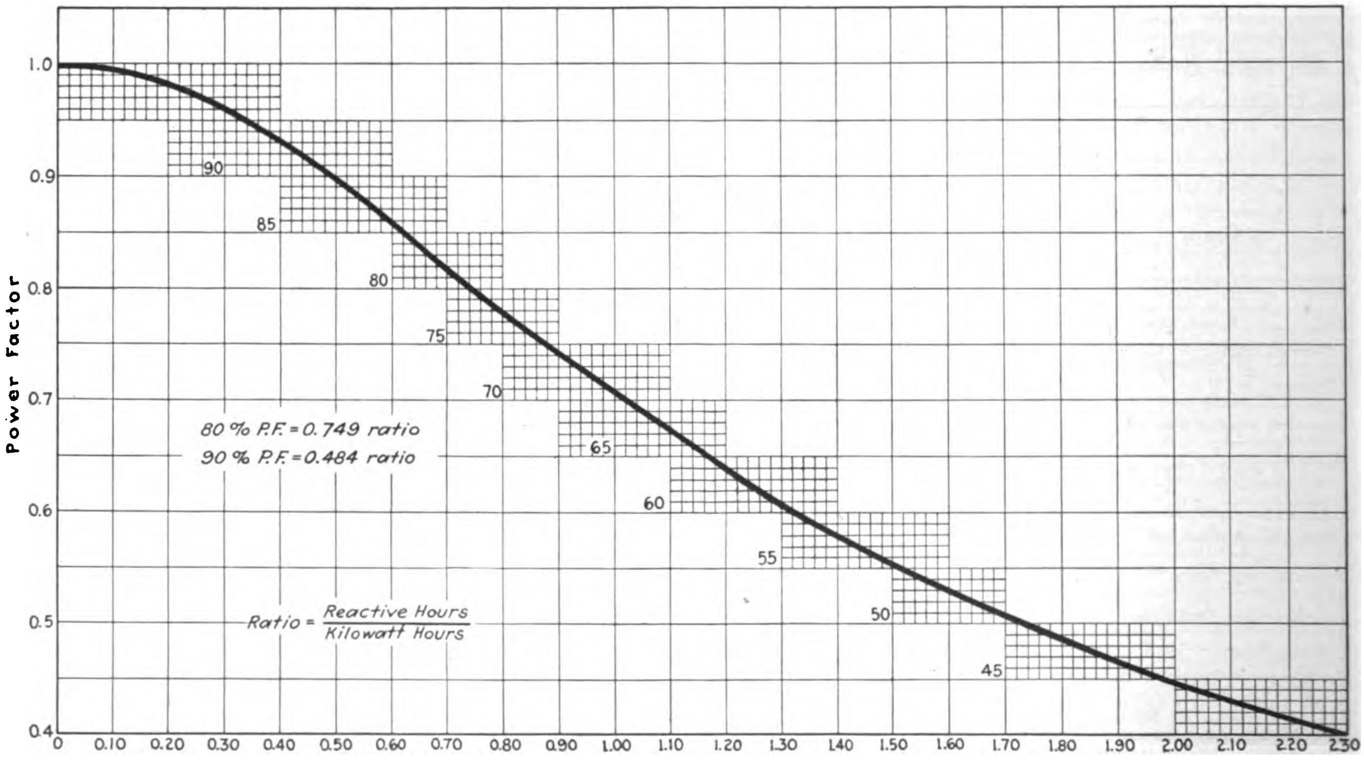
On the other hand, welding equipment and certain types of lighting equipment operate at less than unity power factor and the effect of this load must also be considered.

Probably 80 per cent is about the upper limit of power factor obtainable without the use of corrective equipment in some form, especially where the meters are connected to read the transformer load; but even 80 per cent is far better than the 50 per cent or 60 per cent which is not at all uncommon.

A subsequent article which will appear in an early issue will deal with the various methods of correcting power factor up to a point nearer 100 per cent, or possibly all the way up to 100 per cent, if the savings possible justify it.

Fig. 6—When the ratio of reactive hours to kilowatt-hours is known, the power factor can quickly be determined from this curve.

To find the power factor for any given ratio, locate on the curve the point of intersection of the vertical line corresponding to this ratio, as shown on the abscissa or horizontal line. Thus, in the example given in the text, a ratio of 1.10 is found to represent a power factor of about 67 per cent.



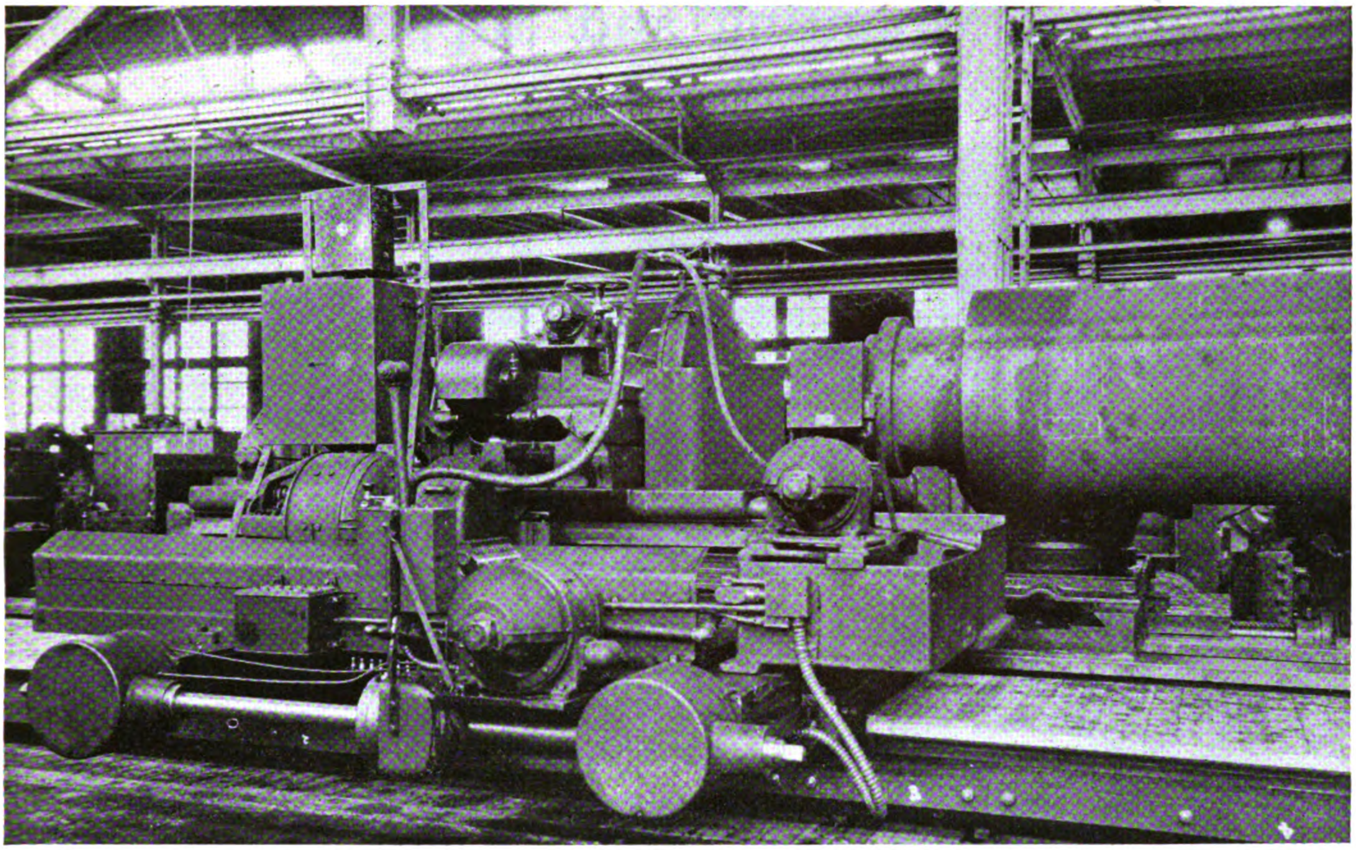


Fig. 1—Here is an excellent method of mounting four motors directly on a 113-in. lathe.

When the driven machine is large with respect to the motor, mounting the motor directly on the machine is very satisfactory. The four motors illustrated here range in size from ½ hp. to 25 hp. and drive different motions of a grinding attachment to a lathe. Some of the motors are mounted directly upon the frame of the lathe, while others are mounted on specially-arranged shelves.

Mounting and Installing Industrial-Type Motors

so as to secure accessibility, reduce vibration, and lower maintenance and repair costs, together with a description of the different types of supports and the relative merits of each

BY GORDON FOX
Electrical Engineer, Freyn Engineering Company, Chicago, Ill.

THE location and manner in which a motor is installed have a great deal to do with the success or failure of a motor drive. Too often a motor is located at a certain place simply because it can be easily bolted down there, with the result that the maintenance and repair charges are excessive. In making a motor installation there are several things that should be considered, the first of which is proper location.

In selecting a location, due regard should be paid to the rules of the National Board of Fire Underwriters and also to any local regulations that may exist. In addition to this, consideration must be given to protection of the motor from moisture, escaping steam, dripping pipes, oil, acid, alkali, chlorine, and other gases, as well as dust, dirt, lint, and other injurious substances. If protection cannot be provided against these troublesome elements, a motor of special construction such as mill type, marine type, splash-proof, force ventilated, and the like should be used. In some cases, particularly with direct-current motors, it may be necessary to build a separate motor room and provide a lineshaft or other form of power transmission to connect the motor to the drive. This is particularly necessary if a direct-current machine is to be used for driving machines placed in a room where any hazardous process is carried on or in places where the motor will be exposed to flammable gases, sawdust, or other combustible material.

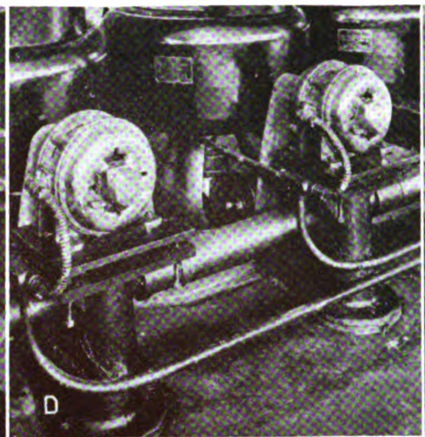
Good ventilation is essential. Motors should not be exposed to excessively high surrounding air temperatures, that is, where the maximum temperature of the windings will be over 90 deg. C.

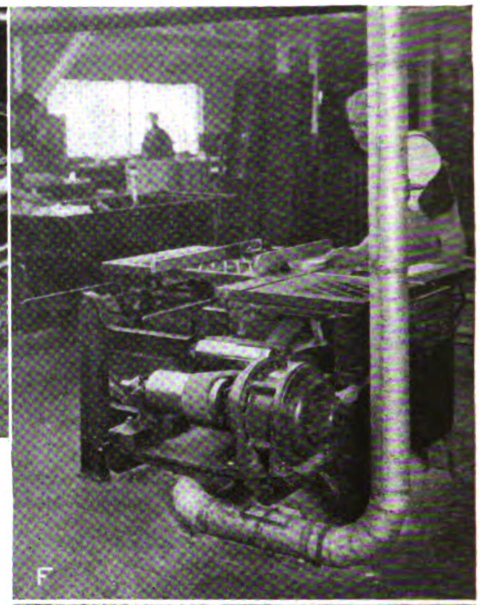
The position of a motor should be such that it is easily accessible for inspection, or else neglect is probable. Clearance spaces should be provided for the removal of the entire motor or its parts. In the case of important machines, care should be exercised to see that broken parts may be quickly replaced. Failing this, the entire motor unit should be exchangeable. It is of advantage to have important motors served by a crane or repair trolley or at least to provide ready means of rigging for handling of motors and parts.

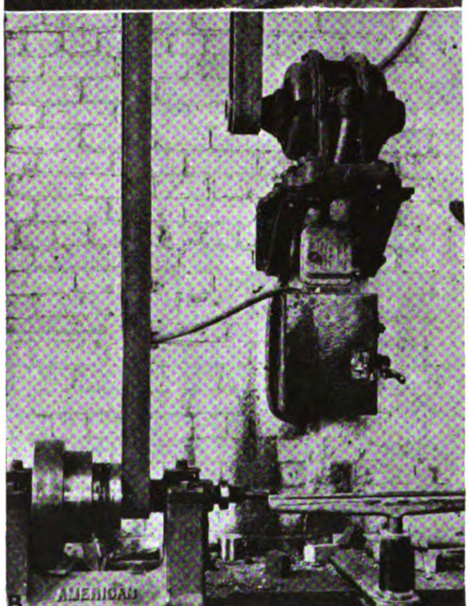
Direct-connected motors are best mounted as an integral part of the driven machine. This is desirable because the machine and drive may then be treated as a unit. It is further desirable for retaining alignment. It is particularly desirable

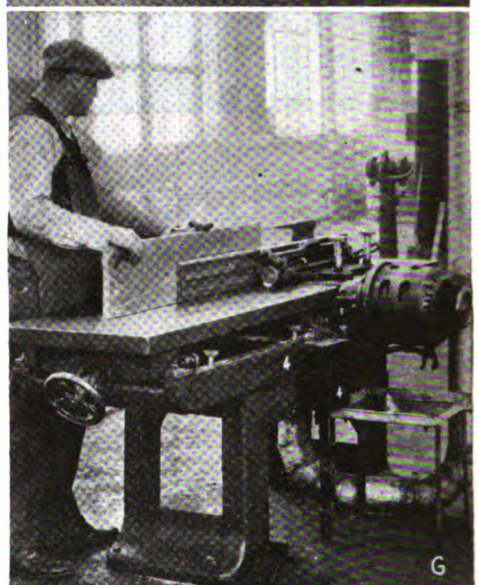
Methods of Mounting and Supporting Motors

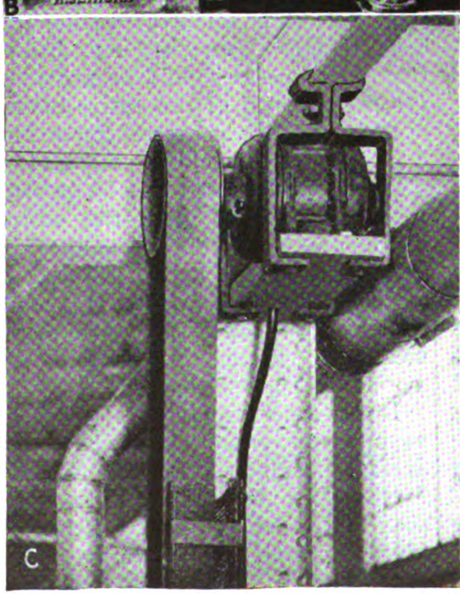
Eight Examples That Have Stood the Test of Service

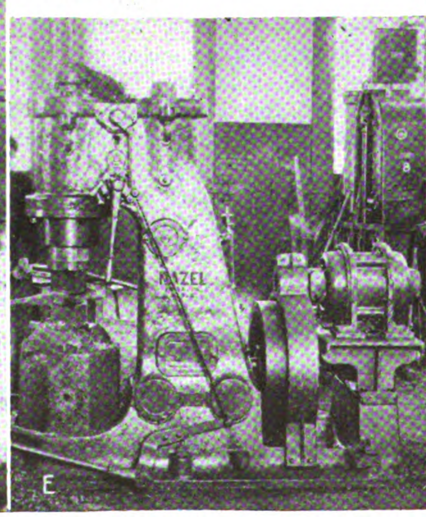


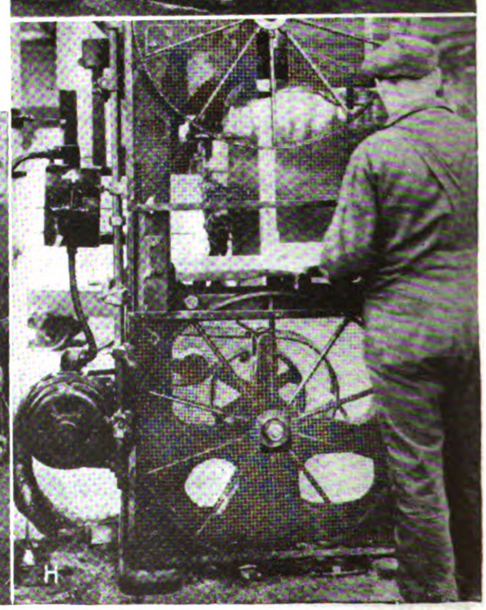












A—Bracket mounting of a small motor that drives a grinder. This arrangement is made up of two angles that are bolted to the flanges of the column. The motor frame is bolted directly to the angles.

B—Bracket mounting of motor on a wall. This mounting is made from steel flats which are bent to the form shown.

C—Clever method of mounting a motor beneath a ceiling I-beam. This support consists of four clamping bars and a wood base fastened together by six bolts.

D—Pedestal mounting of motors to keep them out of the water that usually covers this floor. An angle belt drive is used. As a means of tightening the belt the base may be raised or lowered by four bolts placed at the corners.

E—Another form of pedestal mounting in which the base is integral with the bedplate. Note how accessible the motor is; yet the arrangement is very compact.

F—Compact motor support on a power saw. This support also carries the pedestal bearing required by the wide pulley on the motor.

G—Method of supporting a motor on a high-speed planer. The motor is directly connected to the planer blade and an extra heavy bearing and bracket are provided between the motor and planer to take care of the overhang of the motor.

H—Side mounting of a motor on the frame of a bandsaw. Adjustment of the belt is obtained by an idler pulley.

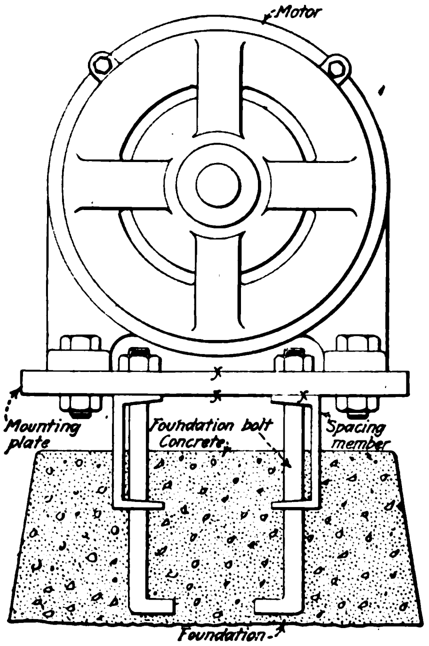


Fig. 2—Mounting on concrete foundation for motor without slide rails.

Two channels are fastened by anchor bolts in a concrete foundation, as shown. Four anchor bolts are used, which also clamp a mounting plate to the channels. With this mounting a motor can be quickly removed or exchanged.

for small machines. For such equipment as pumps, fans, gear reducers, and the like, a common bedplate is usual as shown in Fig. 6. For many other machines some form of bracket or platform is arranged.

The essential requirements of a good foundation or support for a motor are, in brief, (*a*) provision for a firm and solid support for the machine so that it will not settle or otherwise move under the influence of its weight, and (*b*) provision of sufficient weight or rigidity to prevent excessive vibration of the machine if it should be unbalanced or acted upon by unsteady forces. Motors should not be directly attached to or supported by machines which vibrate or shake, as the motors will likely develop trouble under such conditions. Some sort of flexible drive should be used. Railway, mine and mill-type motors are better adapted than general-purpose motors to withstand such conditions.

Care should be exercised to have the motor shaft level; otherwise end-pounding may result. In special cases, where the motor must be mounted with the shaft on a slope, or where pitching may be encountered, ring-oiling bearings should be avoided and some type of ball or roller bearing should be used having suitable end-thrust features. The end-thrust of a driven machine must not be taken by a motor unless special provision is made.

Particular attention must be paid to the type of foundation used. When mounting motors upon a floor, it is advisable to elevate the motor sufficiently to keep it above dirt and moisture, with sufficient space for sweeping. From 6 to 12 in. above the floor is preferred. For belt or chain drives, the sliding base or rails supplied by the motor manufacturer may well be used. Where slide-rails are used care should be exercised to

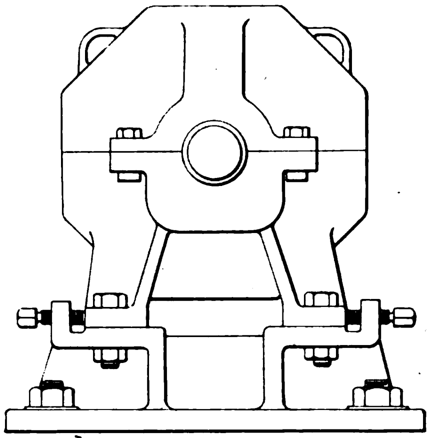


Fig. 3—A mounting that permits of horizontal adjustment of motor to facilitate aligning gears.

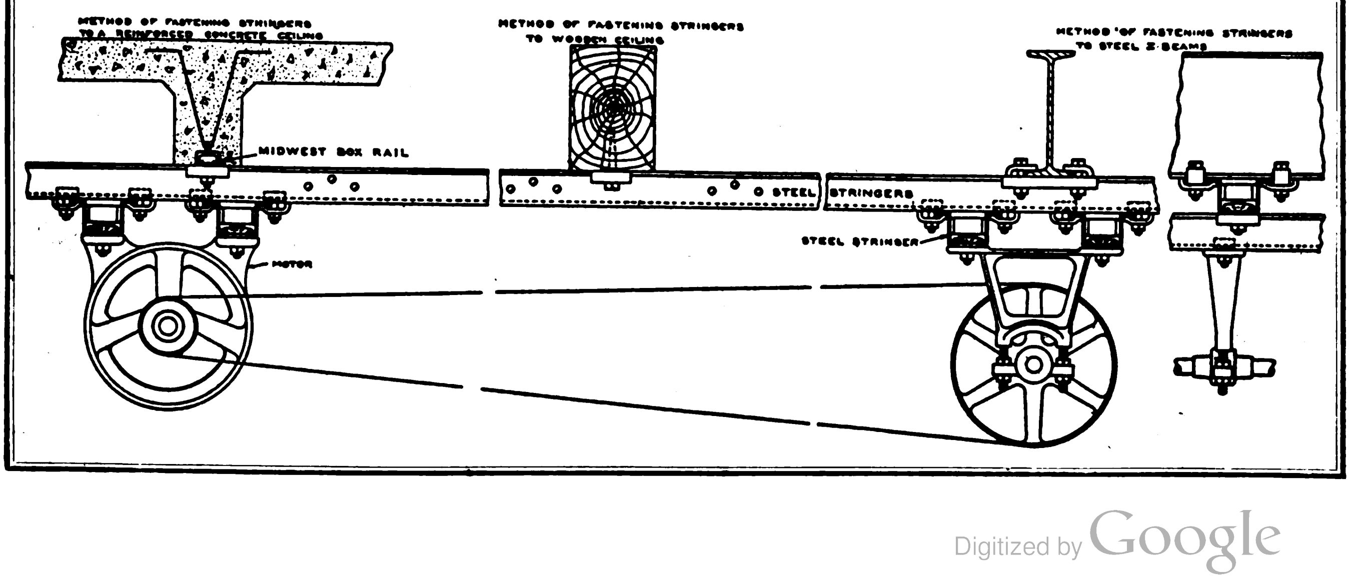
This mounting takes the form of a sub-base on which there are adjusting screws, as shown, to align the motor. In a mill motor of the size shown, two adjusting screws are required on each side as well as two adjusting screws on each end, making a total of eight screws for the motor.

see that they are set to afford a plane surface for the motor to rest upon. Motor bases are usually heavy enough to retain their shape under stress, but they should not be bolted down in a manner to distort them. Slide-rails or bases may be most readily installed by providing a concrete foundation with anchor bolts, the base being aligned with wedges and grouted in. A clever bracket arrangement used on 250 motors by one manufacturer is shown in Fig. 5.

When a direct-connected or geared motor without base is separately mounted on a concrete foundation it should not be grouted in, as removing for exchange or repair is then difficult. Some sort of metal baseplate should be anchored and grouted on the concrete foundation and the motor should then be attached thereto. Fig. 2 shows a motor mounted on castings which are well adapted for this service. A few

Fig. 4—Mounting motors on the ceiling by the use of special steel stringers.

Lineshafts are often supported by the special Midwest Steel & Supply Company's box rails, to which are attached steel stringers, as shown in the illustration. The box rail is cast into the concrete ceiling and fastened by the special reinforcement shown. Steel stringers are then clamped to the box rail and are readily adjustable to any desired position. Additional steel stringers are clamped at right angles to the first mentioned stringers and the motor is fastened to these as is shown in the illustration. This provides for adjustment of the motor in both directions so as to properly align the motor pulley with the driven pulley. A similar arrangement is used for mounting the lineshaft, as is shown at the right of the illustration.



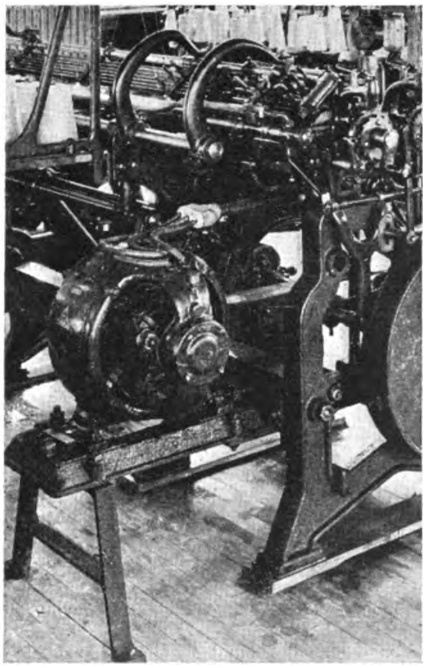


Fig. 5—Over 250 of this type of bracket arrangement for mounting motors are used at one factory.

The mounting consists of one floor bracket and two pieces of strap iron bent at an angle and attached to the frame of the machine, as is shown in the illustration.

such castings can be made to serve a variety of motors.

It is usually a simple matter, in providing a motor support, to so design it that a larger motor or one of different dimensions may be substituted.

This may be easily done by making the support a little larger than required and perhaps by inserting a changeable structural member, a plate, or a filler piece of some kind under the motor feet. The cost of such a provision is insignificant, a good mechanical job can be done, and the leeway allowed may prove invaluable if a change of motors becomes desirable for any reason. Such an installation is shown in Fig. 7.

In attaching a motor to a bedplate or a similar support, through bolts are preferable to capscrews or stud bolts as the motor may be more readily removed and breakage of a bolt is a less serious matter. When motors are mounted on timbers lag-screws are sometimes used to hold down the motor, or the sliding-base or rails. It is a good plan to fill the hole around the lag bolt with molten lead before tightening. Machines larger than 50-kw. capacity should not be mounted on wood timbers.

The use of dowels with direct-coupled or geared motors is common, but by no means universal, practice. This construction does not lend itself to ready interchange of motors. If heavy through bolts are used and these are well tightened, a motor will usually hold its position unless subjected to decided forces. Sometimes a base is provided with set-screws, as shown in Fig. 3, providing means for slight horizontal adjustments and preventing shifting.

Large motors of the pedestal type are usually provided with sole plates if the motor frame is not carried on

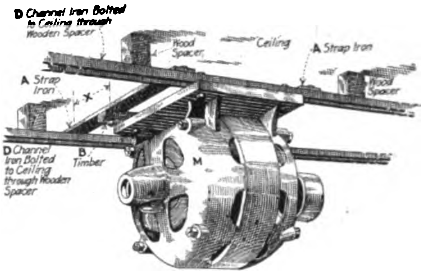


Fig. 8—Method of mounting motor to ceiling by using steel channels that are bolted to the ceiling through wood spacers.

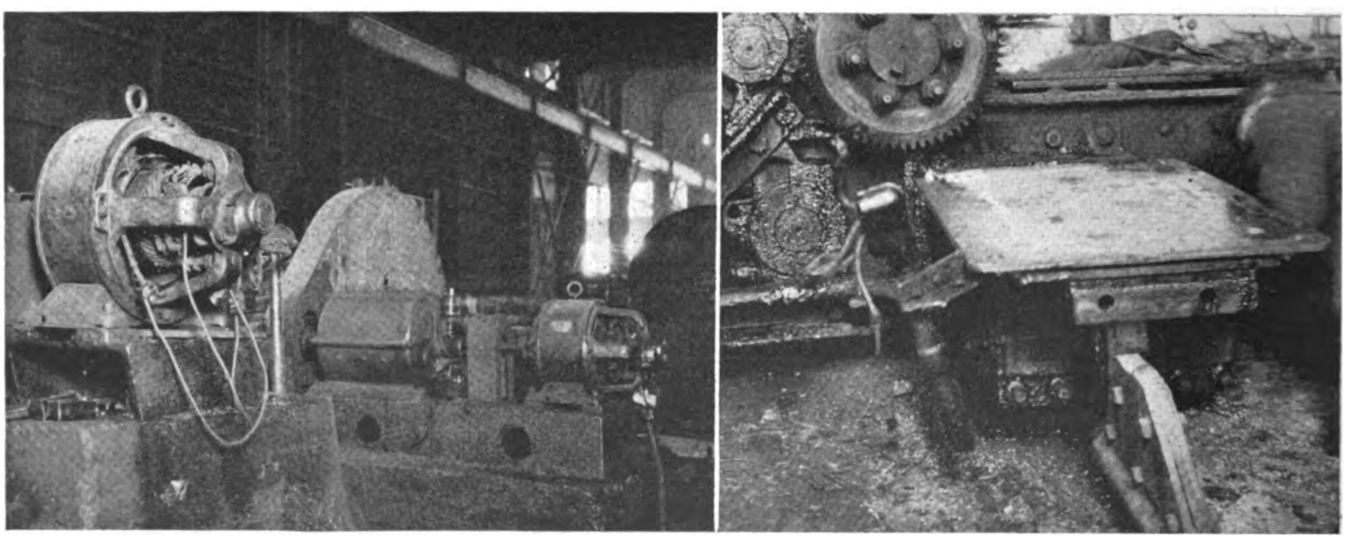
an extension of the base of the driven machine. These sole plates should be wedged into place and grouted in after the motor frame is aligned. It is good practice to provide about ⅛ in. of shims between the motor feet and the sole plate, to allow for future adjustment. Sometimes the motor feet are provided with set-screws for lifting the motor for adjustment of shims. These setscrews should be used for adjustment purposes only and should be relieved during operation.

Particularly in the case of pedestal-type motors, and more commonly for alternating-current machines, it may be desirable to be able to slide the frame for access in making inspections or repairs. This need should be borne in mind when providing bedplates, sole plates, or bases.

The use of a hollow, boxlike base. particularly when made of light structural and plate members, is open to objection because slight vibration may give rise to objectionable noise through the sounding-board effect.

Motors of the general-purpose type may be readily arranged for side wall suspension by shifting the bearing brackets through 90 deg. They may then be bolted directly to the

(Please turn to page 363)



Figs. 6 and 7 — Direct-connected motors are usually mounted on a common bedplate.

Fig. 6 shows such a mounting used in steel mill service. The motor at the right is mounted on a bedplate and connected through a Jones speed reducer to a pipe conveyor. The speed reducer and motor are mounted on the bedplate which is part of the upper end of the conveyor. At the left is shown a motor directly connected to a hot saw. Here again the motor is mounted on a bedplate that is common to the saw and motor. Fig. 7 shows how a motor larger than was originally used, was mounted on a pipe charging crane. A steel plate about 1 in. thick and large enough to accommodate the larger motor was bolted to the original bedplate as shown in the illustration. The larger motor was then attached to the steel plate.

Electric Heating of Liquids and Compounds

together with an analysis of the problems involved and a description of some of the types of equipment available for this purpose

By LEE P. HYNES
President, Hynes & Cox Electric Corporation, Albany, N. Y.

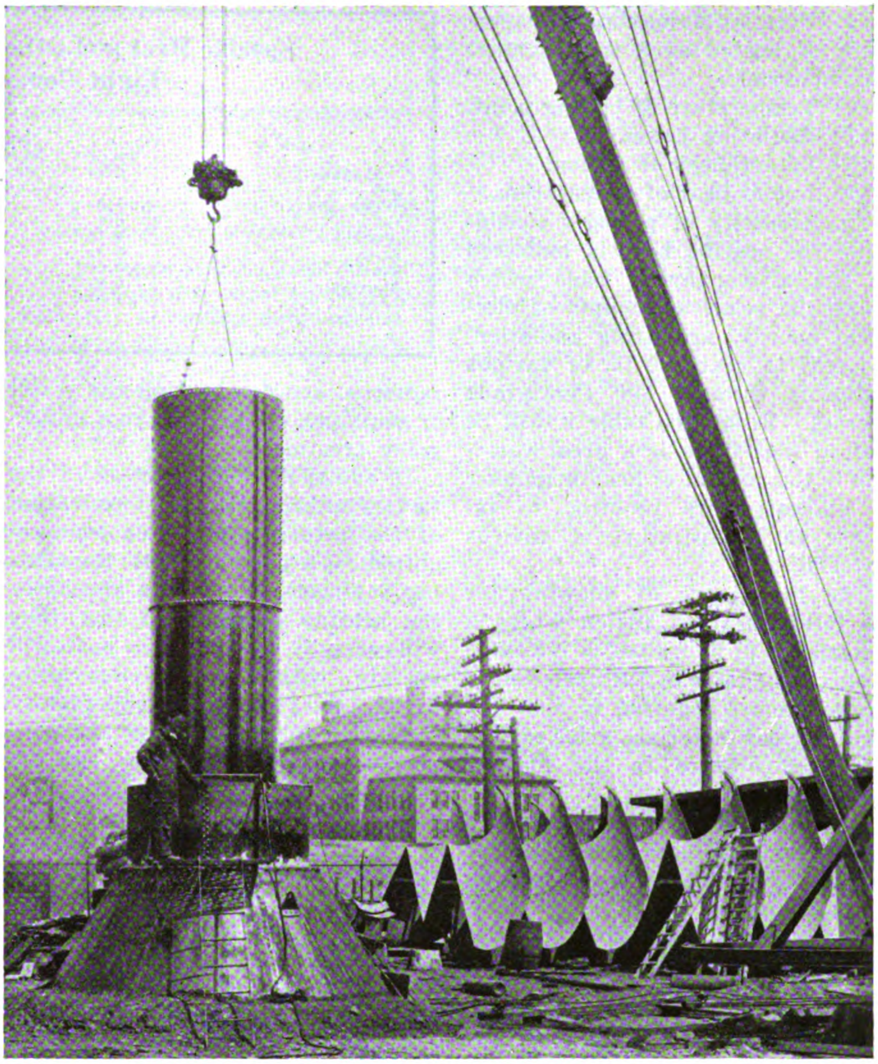


Fig. 1—This 7,000-gal. vertical pitch kettle is electrically heated.
This kettle is 40 ft. deep, the major portion of it being sunk underground to prevent heat losses. The pitch in it is stirred by means of air jets in the bottom of the kettle. Large sections of steel conduit are coated by dipping them in the molten pitch by means of the jib crane, as shown.

HEAT in some form is vital to every industry, but particularly to those dealing with chemicals, liquids and compounds of all kinds. In heating such materials great care is frequently necessary from the standpoints of safety or quality of product, and the problems involved are usually so varied that each case needs careful analysis.

Heating problems of this nature may profitably be divided into three general classes, according to the temperatures required, and the advantages of various heating methods discussed. These classes by temperature ranges are: Low, up to 100 deg. C.; medium, from 100 deg. to 170 deg. C.; and high, 170 deg. to 500 deg. C. For the low-temperature class, steam may be utilized in conjunction with a water bath. In the medium-temperature class steam may be used at pressures corresponding to the required temperature, although the pressure rises to approximately 100 lb. per sq.in. at 170 deg. C. For the high-temperature class, fuel-fired furnaces which employ coal, coke, gas, or oil, may be used.

Electricity, however, is the only heating medium which can be used satisfactorily for all three classes of work. It would be incorrect to claim that it is always the proper means to select. That is a question which depends entirely upon several factors, economic as well as technical. Nevertheless, electricity possesses such flexibility and ease of control, that it can often be used to very great advantage for large and small jobs. The general use of electric motors for power purposes has eliminated high-pressure steam boilers from most plants, except where high-pressure steam is needed for heating in some process. If used intermittently, steam may be inconvenient and expensive, and often electricity could profitably be substituted.

To apply electric heat successfully to any process requires careful design of the equipment and a thorough study of the process. Too often the practical operator who is used to heating by steam fails to appreciate the difference in principle between steam and electric heating. Steam is a constant-temperature medium (at constant pressure) and will give up its heat as rapidly as it can be condensed. Electric heating is exactly opposite in principle, being a constant-input method. This basic difference is clearly illustrated by the curves in the chart given in Fig. 3, which shows the decrease in rate of absorption of heat from the steam by the surface being heated as the temperature of the surface approaches the temperature of the steam. Electricity, on the other hand, generates a constant quantity of heat which must be disposed of and, therefore, the temperature of the heating element will rise until the difference in temperature between it and the surface being heated is sufficient to cause that constant quantity of heat to pass.

In designing any electric heating installation it is necessary to consider at least some of the following items:

(1) Weight of material to be heated per unit of time.
(1) Specific heat of material.
(3) Conductivity of material.
(4) Viscosity of material.

(5) Permissible maximum temperature of heated surface in contact with material.
(6) Temperature of boiling point.
(7) Radiation losses.
(8) Latent heat of fusion.
(9) Latent heat of evaporation.

The necessity of properly considering the specific heat is indicated by the accompanying table which shows the relative amounts of electrical energy, neglecting radiation, required to heat 100 lb. of various materials through 100 Centigrade degrees. From this table it will be noticed that there is a great variation in the amount of heat or number of kilowatt-hours required to increase the temperature of various materials.

Specific Heat and Other Physical Properties of Eight Common Materials

Material	Specific Heat	Kw.-hr. to Raise 100 Lb. 100 Deg. C.	Melting Point Deg. C.	Latent Heat of Fusion B.t.u. per Lb.	Kw.-Hr. to Melt 100 Lb.
Water—Ice	1.0	5.27	0	144.0	4.20
Oil	0.5	2.64	.....	....	....
Aluminum	0.22	1.15	658.7	138.6	4.05
Steel	0.11	0.58	.....	....	....
Tin	0.059	0.31	231.9	25.7	0.75
Mercury	0.033	0.17	.....	....	....
Lead	0.029	0.15	327.0	10.0	0.29
Sulphur	....	....	115.0	16.9	0.49

The importance of allowing for the latent heat of fusion where a material is to be melted is indicated in this same table by the variation in kilowatt-hours required to melt 100 lb. of various materials, after raising their temperature to the melting point.

Hence it is seen that for melting a given substance, heat is required for raising the substance to the melting temperature, as shown in the first two columns of the table and also for converting the substance from the solid state to the liquid as given in the last two columns of the table. Similarly, heat is required for raising a liquid to the boiling point and for converting it from the liquid state to a gaseous form. In addition heat must be supplied to take care of radiation and for heating the vessel or container of the substance undergoing treatment.

In addition to studying all of the factors entering into a determination of the actual quantity of heat required for a particular job, the heating engineer must design and apply the heating elements so that they will correctly distribute the heat, will operate within safe temperature limits, and will have satisfactory insulation for the voltages and temperatures involved. Also suitable regulation for controlling the temperature must be provided.

For small work, portable or stationary heating pots such as are shown in Fig. 2, are useful. These pots can be obtained in several different sizes ranging from 2 to 3 qt. to several gallons' capacity. The 5-gal. size is commonly used for boiling pinions in repair shops before pressing them on motor shafts. These pots are also used for melting alloys such as solder, babbitt, and the like as well as for heating water, oils, and compounds. The cable and control for the pots are detachable for convenience when pouring bearings, splicing cables on poles and the like.

For heating large volumes of liquids of considerable viscosity, or those which may be carbonized or damaged by overheating, it is necessary to provide a constant mechanical circulation. This is sometimes accomplished by means of mechanical stirring devices, sometimes by the introduction of air jets, and sometimes by circulating the material with a pump. For heating oil the last method is usually best. At the lower right of Fig. 2 is an electrically-heated oil tank designed for spraying hot oil on ball bearings during the course of their manufacture. From the spray all surplus oil is drained back to a reservoir and pumped into the heating tank, thus keeping up a constant circulation. The temperature of the oil in the main tank is controlled automatically.

A much larger type of circulating

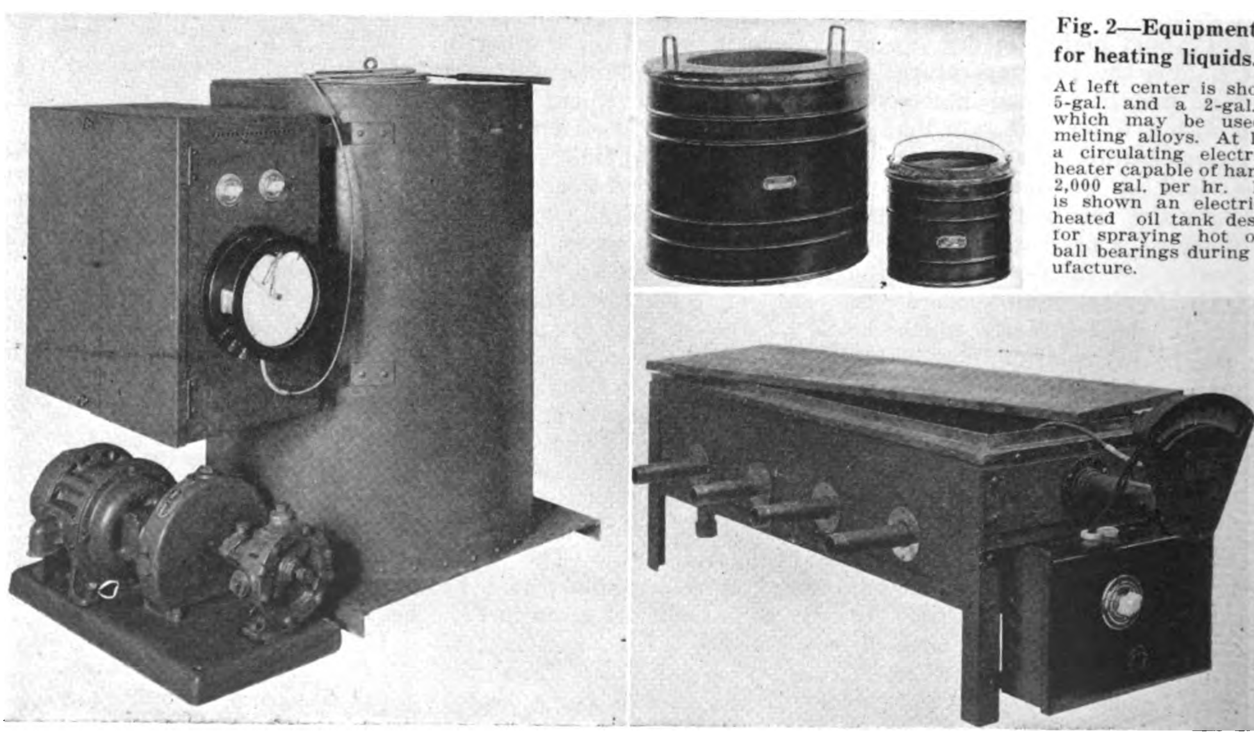


Fig. 2—Equipment used for heating liquids.

At left center is shown a 5-gal. and a 2-gal. pot, which may be used for melting alloys. At left is a circulating electric oil heater capable of handling 2,000 gal. per hr. Below is shown an electrically-heated oil tank designed for spraying hot oil on ball bearings during manufacture.

electric oil heater is shown at left, Fig. 2. It is made in standard sizes to handle as much as 2,000 gal. of oil per hour. It consists of an insulated tank lined with a helical coil of steel pipe through which oil is circulated by an electrically-driven rotary pump. Inside of the pipe coil is a cylindrical electric heater which heats the oil as it passes rapidly through the coil. By properly proportioning the watts per unit of heated coil surface for various velocities of oil circulation, almost any results that may be desired can be obtained.

These ratings will vary for different grades and velocities of oils, but when the proper rating is used there should be no carbonizing of the oil and no deposit of sediment on the interior of the coils, as the scouring action of the moving liquid will prevent this. An equipment of this kind is useful for the uniform heating of large vats of oil for drawing the temper of steel tools and springs. The thorough circulation, combined with automatic control, gives ideal temperature regulation. This method is also useful for preheating heavy fuel oil for large oil furnaces, and also for heating oil for recleaning by centrifugal separators.

A large electrically-heated vertical pitch kettle which holds 7,000 gal. of pitch is shown in Fig. 1. This kettle is 40 ft. deep and 7 ft. 6 in. in diameter, being sunk in the ground and insulated to prevent heat losses to the earth. It is rated at 198 kw., 550 volts, three phase. The pitch is kept constantly stirred by admitting air at a pressure of 100 lb. per sq.in. through jets in the bottom of the kettle.

When dipping large sections of steel conduit, the control is set to maintain the pitch at a uniform temperature of 300 deg. to 400 deg. F., according to the requirements of the particular work in hand.

Many more examples might be cited to show the unique adaptability of electricity for heating large and small tanks, kettles and industrial processes using various liquids and compounds, but in every case success depends upon a correct analysis of the thermal problems involved and their proper solution.

When properly applied, electricity frequently has many advantages for this class of work over any other heating medium. This is especially true for temperatures below the temperature of steam at atmospheric

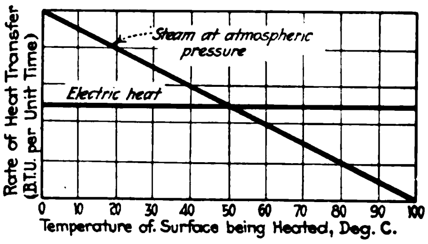


Fig. 3—This shows the basic difference between the use of steam and electricity as heating mediums.

The absorption of heat from steam falls off as the surface being heated approaches that of the steam. Electricity generates a constant quantity of heat; hence this form of heating will cause absorption of a constant quantity of heat.

pressure and for high temperatures, above those available with ordinary saturated steam. Every case, however, is an individual problem of a most interesting nature.

Installation of Motors

(*Continued from page 360*)

wall, to a beam, as shown at *A* on page 358, bolted directly to the side of the driven machine, as shown at *H*, or bolted to a platform or bracket that is fastened to the wall, as shown at *B*, on page 358.

Fastening the motor directly to the wall is the cheaper form of construction and usually provides the stronger support; however, this form of installation is more difficult to align and level and the motor is more inaccessible, which renders inspection and maintenance difficult. For this reason, the bracket or platform support is usually preferred for wall mounting.

A good bracket mounting is shown at *A* on page 358. For larger motors it would be advisable to use angle braces to insure sufficient rigidity. In the case of large motors it is desirable that the platform be made large enough to allow a man to get around to all sides of the motor so as to render inspection easy.

Platforms or mounting brackets are often attached to building columns instead of to walls. In such cases, however, care should be taken that the bending moment or overhang of the motor and platform on the column is not enough to cause trouble. The motor should be placed as close to the column as possible, for the closer it is to the column, the less will be the stress on the latter.

Not infrequently motors are attached to the ceiling. This practice is open to the objection that the motors are not so accessible as when mounted on the floor. However, floor space is often at a premium and in such cases motors must be mounted overhead. In mounting motors on the ceiling the principal feature that requires attention is security of fastening. In general, supports which are secured by bolts passing through the ceiling to the floor above are better than many other forms. Lagscrews, expansion bolts, and similar fastenings should not be used for fastening motors to the ceiling. In buildings having a wood-joist construction the motor can be easily attached to the joists.

In buildings of concrete or steel construction, the use of a double channel iron frame bolted to the ceiling through spacers is suggested as permitting ease of installation and alignment. Such a construction is shown in Fig. 8. In the case of motors driving lineshafts, especially designed, pressed-steel stringers are often used to support the lineshaft hangers and use may be made of them, as shown in Fig. 4, to mount the motor. In this method, box beams are imbedded at intervals in the ceiling, to which steel cross-stringers are clamped. So as to provide adjustment in two directions on a horizontal plane, two stringers are fastened at right angles to the first mentioned stringers and the motor is clamped thereto, as illustrated in Fig. 4.

When there is sufficient space available, it is often preferable to mount a motor in an pright position on a platform suspended from the ceiling. If the distance between the motor and the ceiling is sufficient to accommodate a man, the motor can be easily cleaned and maintained while in place. However, with this form of mounting it is more difficult to prevent movement and vibration than when the motor is attached directly to the ceiling. For this reason the mounting should be rigidly constructed with sufficient cross-bracing. A clever ceiling mounting for a small motor is shown at *C* in the illustrations on page 358.

This article is the first of a series dealing with the mechanical features of motor installation. Succeeding articles which will appear in early issues, will deal with the application of couplings, clutches, belts, chains, gears, speed reducers, and variable-speed transmissions as used to connect the motor to the driven machine.

Some practical information on

Copper Wire That Is Used in Motor Repair Work

together with handy wire tables and an explanation of how they can be employed to save time on everyday and special rewinding jobs

By A. C. ROE
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and
D. H. BRAYMER,
Consulting Editor, Industrial Engineer

THIS IS the first of a series of articles that will deal with the various materials used in motor and generator rewinding and repair jobs. Details will be given of the materials themselves and how they can best be used on a particular machine so as to save time for the repairman and help him to make sure that the results he hopes to get will be realized with the least possible guess-work. This article takes up the most common of all materials used: namely, copper wire, in the shapes and sizes most frequently employed in motor windings. The next article will deal with wire insulation.

THE vitals of a motor or generator are its windings. In spite of extreme care and expert workmanship on a rewinding job, if poor materials are used, or those which are not suited to the service under which the machine must operate, troubles are bound to show up and the repair will be unsatisfactory and expensive to all concerned. But when suitable materials are used under the same circumstances, a rewound motor will give all the service that was expected of it when new.

The base of all windings is copper wire in round, square, ribbon or strap form, and this wire is insulated in various ways by the wire manufacturer. In this article the wire itself will be discussed, and the insulating coverings commonly used will be considered in another article, to appear in an early issue.

The electrical conductivity of copper is second only to that of silver; this feature, combined with good mechanical strength, is the reason for its wide use in electrical windings. For round, strap and ribbon wire used in windings, the conductivity should be not less than 98 per cent. Conductivity of 100 per cent is based on copper having a resistance of 0.1530 ohm per meter gram at 20 deg. C. (68 deg. F.) or 8.306 ohms per square mil foot at 25 deg. C. (77 deg. F.). For calculating weights, etc., the specific gravity of the copper should be taken as 8.89 at 20 deg. C.

The maximum tensile strength in pounds per square inch on tension test should be as follows for round wire and ribbon:

0.003—0.020 in. thick, 40,000 lb.
Elongation 20%
0.020—0.050 in. thick, 38,000 lb.
Elongation 35%
Over 0.050 in. thick, 37,000 lb.
Elongation 30%

The elongation in 10 in. should not be *less* than the percentage given above. These data are for soft-drawn, thoroughly annealed copper wire, ribbon or strap, free from scale, clean and free from cracks, laminations or brittleness. A good grade of wire should be free from joints and all necessary joints should be identical in softness, dimensions, etc., with the main body of the wire. The strength of any joint should be at least 95 per cent of the strength of the clear wire.

A good grade of soft-drawn, square or ribbon copper wire should meet the bending test given in Table I. This test determines the minimum diameter of pin that the wire can be bent around 180 deg. on edge (edgewise) without fracturing or cracking the edges. The dimensions given in Table I are for bare copper and the body of the table gives the diameter of the pin.

A few practical tests can be made which will enable one to judge the grade of wire being supplied. An experienced coil winder can usually tell whether the wire or strap is too hard or springy by the feel of it while forming. It is hard to show this hardness or springiness in figures, but a tension test for per cent of elongation will put it in its proper class.

Soft-drawn, annealed copper becomes hard when worked, that is bent on edge around small pins or bent back and forth a number of times at one spot, but by annealing at about 300 deg. C. (572 deg. F.) it regains its original state, approximately. Copper may be heated to a cherry or dull red and thrown into cold water and cooled quickly, or it can be allowed to cool in the air and it will be equally soft. When the copper is heated to a cherry or dull red heat, it unites with the oxygen in the air and forms one or both of two oxides, which are known as black copper scale and red copper scale. The black scale is infusible, but can be removed by quenching in cold water after annealing. The main points to watch are not to get the copper too hot and to keep the water cold. Most strap copper bent on edge can be annealed around the bends as

Table I—Diameters of Pins to Use in Bending Test for Ribbon and Strap Copper Wire

Bare Wire, Thickness in Inches	Width of Bare Wire in Inches: 0.000 to 0.160	160 to 180	180 to 260	260 to 325	325 to 365	365 to 410	410 to 500
	Diameter of Pin to Use in Inches						
0.025 to 0.030	1/4	3/8	1/2	5/8	5/8	3/4	3/4
0.030 to 0.040	1/4	1/4	3/8	1/2	5/8	5/8	5/8
0.040 to 0.050	1/8	1/4	1/4	3/8	1/2	1/2	5/8
0.050 to 0.062	1/8	1/4	1/4	1/4	3/8	1/2	1/2
0.062 to 0.080	1/8	1/8	1/4	1/4	3/8	3/8	1/2
0.080 up	1/8	1/8	1/4	1/4	1/4	3/8	3/8

described and will not need to be cleaned in acid. In annealing copper, the less air present the smaller will be the amount of scale formed.

Copper does not tarnish in dry air, but in damp air in the presence of carbon dioxide it becomes coated with verdigris or copper carbonate. and the outer surface of the copper turns green. This is quite often seen on wire removed from old machines that have been in service for a number of years. Where untreated material such as cotton, red rope paper, etc., is in close contact with the copper, the cotton or other untreated material absorbs moisture, which in turn forms the verdigris. There does not seem to be any harm resulting from the formation of verdigris on copper at normal winding voltages, but proper baking and dipping will reduce, and in some cases prevent, the formation of this verdigris. Soldering acids (zinc chloride solution) and some soldering pastes also form this verdigris on the copper with this difference: the corrosion penetrates and attacks the insulating material.

When copper wire is to be rubber covered, the wire is first tinned, as the sulphur in the rubber attacks the copper, forming copper sulphide. Tin is not affected by sulphur.

Wire that is used for windings of electrical machines can be classified according to diameter, width, thickness, etc. The B & S wire gage is usually used in the United States. A complete history of the wire tables, sizes, etc., will be found in Circular No. 31 of the Bureau of Standards, Washington, D. C. (Price 10 cents.)

Table II—Resistance and Dimensions of Standard, Annealed, Round B & S Gage Copper*

Gauge No.	Diameter in Mils.	Cross Section		Pounds per 1000 Feet	Feet per Pound	Resistance of Pure Copper at 25° C. (=77° F.)			
		Circular Mils.	Square Inches			Ohms per 1000 Feet	Feet per Ohm	Pounds per Ohm	Ohms per Pound
0000	460.0	211600.	.1662	640.5	1.561	.04998	20010.	12810.	.00007805
000	409.6	167800.	.1318	507.9	1.968	.06303	15870.	8057.	.0001241
00	364.8	133100.	.1045	402.8	2.482	.07947	12580.	5067.	.0001974
0	324.9	105500.	.08289	319.5	3.130	.1002	9979.	3187.	.0003138
1	289.3	83690.	.06573	253.3	3.947	.1264	7913.	2004.	.0004990
2	257.6	66370.	.05213	200.9	4.977	.1594	6276.	1260.	.0007934
3	229.4	52640.	.04134	159.3	6.276	.2009	4977.	792.7	.001262
4	204.3	41740.	.03278	126.4	7.914	.2534	3947.	498.6	.002006
5	181.9	33100.	.02600	100.2	9.980	.3195	3130.	313.5	.003189
6	162.0	26250.	.02062	79.46	12.58	.4029	2482.	197.2	.005071
7	144.3	20820.	.01635	63.02	15.87	.5080	1968.	124.0	.008064
8	128.5	16510.	.01297	49.98	20.01	.6406	1561.	77.99	.01282
9	114.4	13090.	.01028	39.63	25.23	.8078	1238.	49.05	.02039
10	101.9	10380.	.008155	31.43	31.82	1.019	981.8	30.85	.03242
11	90.74	8234.	.006467	24.92	40.12	1.284	778.5	19.40	.05155
12	80.81	6530.	.005129	19.77	50.59	1.620	617.4	12.20	.08196
13	71.96	5178.	.004067	15.68	63.80	2.042	489.6	7.673	.1303
14	64.08	4107.	.003225	12.43	80.44	2.576	388.3	4.826	.2072
15	57.07	3257.	.002558	9.858	101.4	3.248	307.9	3.035	.3296
16	50.82	2583.	.002028	7.818	127.9	4.095	244.2	1.909	.5239
17	45.26	2048.	.001609	6.200	161.3	5.164	193.7	1.200	.8330
18	40.30	1624.	.001276	4.917	203.4	6.512	153.6	.7549	1.325
19	35.89	1288.	.001012	3.899	256.5	8.210	121.8	.4748	2.106
20	31.96	1022.	.0008023	3.092	323.4	10.35	96.59	.2986	3.349
21	28.46	810.1	.0006363	2.452	407.8	13.06	76.60	.1878	5.325
22	25.35	642.4	.0005046	1.945	514.2	16.46	60.74	.1181	8.467
23	22.57	509.5	.0004002	1.542	648.4	20.76	48.17	.07427	13.46
24	20.10	404.0	.0003173	1.223	817.7	26.18	38.20	.04671	21.41
25	17.90	320.4	.0002517	.9699	1031.	33.01	30.30	.02938	34.04
26	15.94	254.1	.0001996	.7692	1300.	41.62	24.02	.01847	54.13
27	14.20	201.5	.0001583	.6100	1639.	52.48	19.05	.01162	86.07
28	12.64	159.8	.0001255	.4837	2067.	66.18	15.11	.007307	136.8
29	11.26	126.7	.00009953	.3836	2607.	83.46	11.98	.004595	217.6
30	10.03	100.5	.00007894	.3042	3287.	105.2	9.503	.002890	346.0
31	8.928	79.70	.00006260	.2413	4145.	132.7	7.536	.001818	550.2
32	7.950	63.21	.00004964	.1913	5227.	167.3	5.976	.001143	874.8
33	7.080	50.13	.00003937	.1517	6591.	211.0	4.739	.0007189	1391.
34	6.305	39.75	.00003122	.1203	8310.	266.1	3.759	.0004521	2212.
35	5.615	31.52	.00002476	.09542	10480.	335.5	2.981	.0002843	3517.
36	5.000	25.00	.00001964	.07568	13210.	423.0	2.364	.0001788	5592.
37	4.453	19.83	.00001557	.06001	16660.	533.5	1.874	.0001125	8892.
38	3.965	15.72	.00001235	.04759	21010.	672.7	1.487	.00007074	14140.
39	3.531	12.47	.000009793	.03774	26500.	848.2	1.179	.00004448	22480.
40	3.145	9.888	.000007766	.02993	33410.	1070.	.9349	.00002798	35740.

*From Bureau of Standards Circular No. 81.

NOTE: The values given in the table are only for annealed copper of the standard resistivity. The user of the table must apply the proper correction for copper of any other resistivity. Hard-drawn copper may be taken as about 2.7 per cent higher resistivity than annealed copper.

Table III—Equivalent Cross-Sections of Bare, Solid and Stranded B & S Gage Wires*

Size	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	0	Size
0000	2105	1670	1324	1050	833	661	524	415	329	261	207	164	130	103	82	65	52	41	32	26	20	16	13	10	8	6	5	4	2	0000
000	1670	1324	1050	833	661	524	415	329	261	207	164	130	103	82	65	52	41	32	26	20	16	13	10	8	6	5	4			000
00	1324	1050	833	661	524	415	329	261	207	164	130	103	82	65	52	41	32	26	20	16	13	10	8	6	5	4				00
0	1050	833	661	524	415	329	261	207	164	130	103	82	65	52	41	32	26	20	16	13	10	8	6	5	4			2	1	0
1	833	661	524	415	329	261	207	164	130	103	82	65	52	41	32	26	20	16	13	10	8	6	5	4			2			1
2	661	524	415	329	261	207	164	130	103	82	65	52	41	32	26	20	16	13	10	8	6	5	4			2				2
3	524	415	329	261	207	164	130	103	82	65	52	41	32	26	20	16	13	10	8	6	5	4			2			1		3
4	415	329	261	207	164	130	103	82	65	52	41	32	26	20	16	13	10	8	6	5	4			2			1			4
5	329	261	207	164	130	103	82	65	52	41	32	26	20	16	13	10	8	6	5	4			2			1				5
6	261	207	164	130	103	82	65	52	41	32	26	20	16	13	10	8	6	5	4			2			1					6
7	207	164	130	103	82	65	52	41	32	26	20	16	13	10	8	6	5	4			2			1						7
8	164	130	103	82	65	52	41	32	26	20	16	13	10	8	6	5	4			2			1							8
9	130	103	82	65	52	41	32	26	20	16	13	10	8	6	5	4			2			1								9
10	103	82	65	52	41	32	26	20	16	13	10	8	6	5	4			2			1									10
11	82	65	52	41	32	26	20	16	13	10	8	6	5	4			2			1										11
12	65	52	41	32	26	20	16	13	10	8	6	5	4			2			1											12
13	52	41	32	26	20	16	13	10	8	6	5	4			2			1												13
14	41	32	26	20	16	13	10	8	6	5	4			2			1													14
15	32	26	20	16	13	10	8	6	5	4			2			1														15
16	26	20	16	13	10	8	6	5	4			2			1															16
17	20	16	13	10	8	6	5	4			2			1																17
18	16	13	10	8	6	5	4			2			1																	18
19	13	10	8	6	5	4			2			1																		19
20	10	8	6	5	4			2			1																			20
21	8	6	5	4			2			1																				21
22	6	5	4			2			1																					22
23	5	4			2			1																						23
24	4			2			1																							24
Size	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	0	Size

*Rome Wire Company.

NOTE: The upper and lower lines of figures indicate the sizes. The body of the table gives the number of wires equivalent in cross-section to the sizes in the right and left margins.

Table II gives the standard American wire gage (B & S) data for bare round copper wire. This table is taken from the above circular. The cross-sectional area of all wire in this series of articles will be given both in circ.mils and square inches for round and square wire, and in square inches only for ribbon and strap forms.

In writing up coil specifications covering round wire the decimal size of the wire will be found more convenient than the B & S gage number. For example: 50 lb. of 0.0641 round copper magnet wire.

Wire Table Short Cuts.—Since the American (B & S) wire gage is formed by geometrical progression, there are a number of easily remembered ratios that will enable one to compute any wire size ratings without the necessity of referring to a

wire table. These figures will be correct to within 2 per cent.

The resistance, mass, and cross-section of round wire vary with the square of the diameter. The next size larger or smaller than any given size is 1.26 $\times$ X or $X \div 1.26$, where X is the circ.mil area of the known size. For example: Take a No. 10 (0.1019 in.) wire which has an area of 10,380 circ. mils. Then 1.26 $\times$ 10,380 = 13,084 circ. mils, which according to Table II is a No. 9 wire. Also, 10,380 $\div$ 1.26 = 8,238 circ. mils, which is No. 11 wire.

For every ten gage sizes the resistance, pounds per 1,000 ft., and cross-section are divided by 10 or multiplied by 10. For example: A No. 20 wire is $\frac{1}{10}$ the area of a No. 10, and a No. 20 has ten times the resistance of a No. 10, etc.

Every third larger gage number is twice the area, and every third smaller gage number is one-half the area of any given wire size. For example: A No. 10 wire has an area of 10,380 circ. mils; then 10 plus 3 or No. 13 wire has an area of 5,178 circ. mils. When one line of the wire table is memorized, the data for any other gage size can be computed for rough work by these approximate rules.

The cross-sectional area of round, square, and ribbon wire is usually given in circular mils. The cross-section in circular mils of a single wire is the square of its diameter in mils. The mils equal the diameter in inches times 1,000. If D equals the diameter in mils, circ. mils equal $D \times D$. Thus, the diameter of a No. 10 wire is 0.1019 in.; then D in mils equals 0.1019 $\times$ 1,000 = 101.9, and the circ. mils equal 101.9 $\times$ 101.9 or 10,836.

In computing the cross-sectional area of square or ribbon wire and copper strap, the copper loss in the rounding of the corners must be taken into consideration. The cross-section of copper strap is generally given in square inches. Then to compare a strap with a ribbon or round wire, it is necessary to convert the square inches to circular mils. Circ. mils equals sq.in. $\div$ 0.000,000,7854. A quicker method is to divide the sq.in. by 1,000,000 and then divide the result by 0.7854.

Table III is a very handy one for the repairman. This table gives the number of B & S gage wires equivalent to one large wire. For example, the first and last vertical columns give the B & S gage size from 0000 to 24. The top and bottom horizontal lines give the B & S size from 0 to 30. By consulting the horizontal line for No. 8 wire, we find that one No. 8 is equal to 164 No. 30 wires, 130 No. 29 wires, etc.

This is a handy table when a rush job comes up and the required wire size is not in stock. It shows all the

Table IV—Outside Diameter of Round Copper Wires with Different Types of Insulating Coverings

B & S Gauge Size	Cross Section		Diameter of Wire Over Insulation in Inches										
	Circular Mils	Square Inches	Bare Diameter in Inches	Enamel Covered (EN)	Single Cotton Covered (S-C-C)	Double Cotton Covered (D-C-C)	Single Cotton and Enamel (S-C-EN)	Double Cotton and Enamel (D-C-C-EN)	Triple Cotton Covered (T-C-C)	Single Silk Covered (S-S-C)	Double Silk Covered (D-S-C)	Single Silk and Enamel (S-S-EN)	Double Silk and Enamel (D-S-EN)
0000	211,600	0.1662	0.4600	....	0.4690	0.4780	....	....	0.4870	....	....	....	....
000	167,800	0.1318	0.4096	....	0.4186	0.4276	....	....	0.4366	....	....	....	....
00	133,100	0.1045	0.3648	....	0.3738	0.3828	....	....	0.3918	....	....	....	....
0	105,500	0.08289	0.3249	....	0.3319	0.3429	....	....	0.3519	....	....	....	....
1	83,690	0.06573	0.2893	....	0.2983	0.3073	....	....	0.3163	....	....	....	....
2	66,370	0.05213	0.2576	....	0.2666	0.2756	....	....	0.2846	....	....	....	....
3	52,640	0.04[illegible]34	0.2294	....	0.2384	0.2474	....	....	0.2564	....	....	....	....
4	41,740	0.03278	0.2043	....	0.2133	0.2223	....	....	0.2313	....	....	....	....
5	33,100	0.02600	0.1819	....	0.1909	0.1999	....	....	0.2089	....	....	....	....
6	26,250	0.02062	0.1620	....	0.1700	0.1780	....	....	0.1860	....	....	....	....
7	20,820	0.01635	0.1443	....	0.1523	0.1603	....	....	0.1683	....	....	....	....
8	16,510	0.01297	0.1285	0.1300	0.1355	0.1425	0.1355	0.1410	0.1495	....	....	....	....
9	13,090	0.01028	0.1144	0.1164	0.1204	0.1264	0.1220	0.1274	0.1324	....	....	....	....
10	10,380	0.00816	0.1019	0.1038	0.1069	0.1119	0.1093	0.1148	0.1169	....	....	....	....
11	8,234	0.00647	0.0907	0.0927	0.0957	0.1007	0.0882	0.1037	0.1057	....	....	....	....
12	6,530	0.00513	0.0808	0.0828	0.0858	0.0908	0.0883	0.0938	0.0958	....	....	....	....
13	5,178	0.00407	0.0720	0.0740	0.0770	0.0820	0.0795	0.0850	0.0860	....	....	....	....
14	4,107	0.00323	0.0641	0.0660	0.0691	0.0731	0.0715	0.0770	0.0781	....	....	....	....
15	3,257	0.00256	0.0571	0.0585	0.0621	0.0661	0.0640	0.0695	0.0711	0.0591	0.0610	0.0607	0.0627
16	2,583	0.00203	0.0508	0.0523	0.0558	0.0598	0.0573	0.0623	0.0648	0.0528	0.0547	0.0543	0.0563
17	2,048	0.00161	0.0453	0.0467	0.0502	0.0542	0.0517	0.0563	0.0592	0.0472	0.0491	0.0486	0.0506
18	1,624	0.00128	0.0403	0.0418	0.0453	0.0493	0.0468	0.0518	0.0543	0.0423	0.0442	0.0437	0.0457
19	1,288	0.00101	0.0359	0.0374	0.0409	0.0449	0.0424	0.0474	0.04[illegible]9	0.0379	0.0398	0.0393	0.0413
20	1,022	0.000802	0.03196	0.0334	0.0370	0.0410	0.0379	0.0424	0.0460	0.0340	0.0359	0.0352	0.0371
21	810.1	0.000636	0.02846	0.0294	0.0335	0.0375	0.0339	0.0384	0.0425	0.0305	0.0324	0.0316	0.0335
22	642.4	0.000505	0.02535	0.0263	0.0303	0.0343	0.0308	0.0353	0.0393	0.0273	0.0292	0.0285	0.0304
23	509.5	0.000400	0.02257	0.0236	0.0276	0.0316	0.0281	0.0326	0.0366	0.0246	0.0265	0.0256	0.0275
24	404.0	0.000317	0.02010	0.0210	0.0251	0.0291	0.0255	0.0300	0.0[illegible]41	0.0221	0.0240	0.0232	0.0251
25	320.4	0.000252	0.01790	0.0187	0.0229	0.0269	0.0232	0.0277	0.031[illegible]	0.0199	0.0218	0.0209	0.0228
26	254.1	0.0001996	0.01594	0.0167	0.0209	0.0249	0.0207	0.0247	0.0299	0.0179	0.0198	0.0189	0.0208
27	201.5	0.0001583	0.01420	0.0149	0.0192	0.0232	0.0189	0.0229	0.0282	0.0162	0.0180	0.0171	0.0189
28	159.8	0.0001255	0.01264	0.0133	0.0176	0.0216	0.0173	0.0213	0.0266	0.0146	0.0164	0.0155	0.0173
29	126.7	0.0000995	0.01126	0.0120	0.0163	0.0203	0.0160	0.0200	0.0253	0.0133	0.0149	0.0140	0.0156
30	100.5	0.00007894	0.01003	0.0107	0.01502	0.01802	0.0147	0.0187	0.02402	0.01202	0.01362	0.01285	0.01445
31	79.70	0.00006260	0.008928	0.0094	0.01392	0.01792	0.0134	0.0174	0.02292	0.01092	0.01252	0.01167	0.01327
32	63.21	0.00004964	0.007950	0.0084	0.01295	0.01695	0.0124	0.0164	0.02195	0.00995	0.01155	0.01065	0.01225
33	50.13	0.00003937	0.007080	0.0075	0.01208	0.01608	0.0115	0.0155	0.02108	0.00908	0.01068	0.00973	0.01133
34	39.75	0.00003122	0.006305	0.0068	0.01130	0.01530	0.0108	0.0148	0.02030	0.00830	0.00990	0.00890	0.01050
35	31.52	0.00002476	0.005615	0.0060	0.01061	0.01461	0.0100	0.0140	0.01961	0.00761	0.00921	0.00816	0.00976
36	25.00	0.00001964	0.005000	0.0054	0.01000	0.01400	0.0094	0.0134	0.01900	0.00700	0.00860	0.00750	0.00910
37	19.83	0.00001557	0.004453	0.0048	0.00945	0.01345	0.0088	0.0128	0.01845	0.00645	0.00805	0.00694	0.00854
38	15.72	0.00001235	0.003965	0.0043	0.00896	0.01296	0.0083	0.0123	0.01786	0.00596	0.00756	0.00639	0.00799
38	12.47	0.00000979	0.003531	0.0038	0.00853	0.01253	0.008[illegible]6	0.01296	0.01753	0.00553	0.00713	0.00596	0.00756
40	9.888	0.00000777	0.003145	0.0033	0.00814	0.01214	0.00857	0.01257	0.01714	0.00514	0.00674	0.00557	0.00717

possible combinations that will give the same cross-sectional area of copper. Of course, the space factor (room in the slot) and the mechanical arrangement of the wires in the slot will be the deciding factors on the number of smaller wires that can be used. On the other hand, assume that an old type machine is being considered, having partly closed slots with large conductors and a shove-through type of winding of low voltage. The table will indicate the number of wires in hand of the size that will go through the slot opening, to permit the use of a mush coil, two-layer winding.

For example, assume that the old winding used a No. 9 wire and that the slot opening would allow a No. 16 wire to pass. We then find No. 16 in the top horizontal line and look down this column to the No. 9 line where we find the figure 5 which means that five No. 16 wires are equal to one No. 9. In the above example the five No. 16 bare wires will have the same copper cross-sectional area as the one No. 9 wire, but the room required in the slot for the five wires will be greater due to there being more cotton insulating material that must be considered.

Copper wire, round, square, ribbon or strap, must be insulated before being used in the construction of electrical windings. For round wires, this insulation may consist of coating the wire with enamel, or wrapping it with one, two or three layers of cotton or silk, or using an asbestos covering, or some combination of the above. The following are the various insulations applied to wire and the standard abbreviations used to designate each covering:

(1) Enamel covered wire.........En.
(2) Single cotton covered......S.C.C.
(3) Double cotton covered.....D.C.C.
(4) Triple cotton covered......T.C.C.
(5) Single silk covered........S.S.C.
(6) Double silk covered.......D.S.C.
(7) Single cotton and enamel covered .............S.C.&En.
(8) Double cotton and enamel covered .............D.C.&En.
(9) Triple cotton and enamel covered .............T.C.&En.
(10) Single silk and enamel covered ..............S.S.&En.
(11 Double silk and enamel covered .............D.S.&En.
(12) Asbestos covered. There are three grades of asbestos coverings; these will be explained later under the proper heading.
(13) Asbestos covering with one or two reinforcing coverings of cotton.

Table IV gives the over-all diameters of the B & S gage round wires when insulated with the coverings above listed as 1 to 11.

Table V—Dimensions, Weight and Resistance of Round, Enamel-Covered Magnet Wire

B. & S. Gage	Diameter Bare Wire in Inches	Feet per Pound	Pounds per 1,000 Feet	Ohms per Pound	Pounds per Ohm
8	0.1280	19.9	50.2	0.0125	80.0
9	0.1144	25.1	39.8	0.0198	50.5
10	0.1018	31.6	31.6	0.0315	31.7
11	0.0907	39.8	25.1	0.0500	20.0
12	0.0808	50.2	19.9	0.0796	12.6
13	0.0719	63.2	15.8	0.126	7.94
14	0.0641	79.6	12.6	0.201	4.97
15	0.0571	100	10.0	0.318	3.14
16	0.0508	125	7.94	0.505	1.98
17	0.0453	160	6.25	0.809	1.24
18	0.0403	202	4.95	1.29	0.775
19	0.0359	254	3.94	2.04	0.490
20	0.0320	319	3.14	3.24	0.319
21	0.0285	402	2.49	5.14	0.195
22	0.0253	506	1.98	8.16	0.123
23	0.0226	638	1.57	13.0	0.0770
24	0.0201	804	1.24	20.6	0.0485
25	0.0179	1,010	0.990	32.6	0.0307
26	0.0159	1,280	0.782	52.2	0.0192
27	0.0142	1,610	0.621	82.7	0.0121
28	0.0126	2,030	0.492	132	0.00758
29	0.0113	2,560	0.391	209	0.00478
30	0.0100	3,220	0.311	332	0.00301
31	0.0089	4,050	0.247	527	0.00190
32	0.0079	5,100	0.196	835	0.00120
33	0.0071	6,420	0.156	1,330	0.00075
34	0.0063	8,080	0.124	2,100	0.00048
35	0.0056	10,200	0.098	3,350	0.00030
36	0.0050	12,800	0.0782	5,300	0.00019
37	0.0044	16,100	0.0621	8,410	0.00012
38	0.0040	20,300	0.0492	13,400	0.000075
39	0.0035	25,500	0.0392	21,200	0.000047
40	0.0031	32,100	0.0312	33,600	0.000030

Enamel Covered Magnet Wire.—This wire is mostly used in small magnet and field coils and in winding small armatures such as are used in vacuum cleaners, small drills, etc., and is also used to some extent for small shunt field coils.

Bare copper wire should have the characteristics already explained and the enamel covering should have the following good features:

The enamel should adhere strongly to the wire and should not crack or split when subjected to the following test: Bake a sample at 100 to 110 deg. C. for at least 24 hr. and then bend it around a mandrel having a diameter of 1½ times the diameter of the wire for 0.0179-in. and smaller wire, or three times the diameter for 0.02-in. to 0.04-in., and four times the diameter for wire 0.04 in. and above. Under this test the enamel should not crack or peel and when subjected to an elongation test, a piece 10 in. long should elongate at least 25 per cent before cracking or peeling. This covering should not soften when subjected to baking at a temperature of 100-115 deg. C. for a period of at least 5 hr. A slight stickiness is an indication of softening of the enamel coating.

The enamel covering on the wire is generally tested by the wire manufacturers for bare or weak spots by passing the wire through a mercury bath at the rate of 600 ft. per minute; the voltage between the mercury and copper ranges between 25 and 75 volts direct current, according to the diameter of the wire. The number of faults per 100 ft. is used as the base upon which the wire is passed.

Other electrical tests can be made as follows: Wind at least ten turns around a metal mandrel ⅜ in. in diameter, the surface of which is smooth, that is free from burrs, lumps, etc.; then test between the wire and mandrel with direct current. The wire should stand at least 500 volts for 1 min., or the voltage can be increased until breakdown occurs. This test will indicate what one thickness of covering will stand.

To test between layers, wind two layers of the wire, one on top of the other, on a smooth mandrel approximately ½ in. in diameter. Each layer should be at least 1 in. long. Then apply direct current voltage between layers. The enamel should

stand at least 500 to 1,000 volts before breakdown occurs.

The above tests will indicate the quality of the wire, but will not guarantee that the wire will stand up under abuse. For example, in winding small field coils, if the tension is applied to the rim of the reel or spool on which the wire is wound, care must be taken that the tension is not too great, as in this case the wire will be imbedded in the layers on the reel, causing rubbing and peeling of the enamel. Also, if a heavy tension is used and the winding machine is started with a jerk, the snap imparted to the wire will tend to crack the enamel. These points are mentioned because when trouble is experienced with coils wound with enameled wire it is usually some small detail of the method of applying the wire or handling it that causes the trouble.

Passing enameled wire through clamps will cause trouble if the wire is clamped too tight. The rubbing or friction generates heat which tends to soften the enamel and, in conjunction with the rubbing action, weakens the covering. Proof that the clamp generates heat can be found by feeling the wire on each side of a clamping block while an armature is being banded.

Transformer or lubricating oils, or any material having an oil base, have practically no effect on enameled wire over long periods of time. The commercial grades of kerosene, benzine, naphtha, and gasoline have, however, a slight effect, but it would take hours of soaking to dissolve the enamel coating. High-test gasoline, turpentine and coal tar products, such as benzol, have a solvent action.

All alkalis have a bad effect on the enamel coating, and the stronger caustics, potassium and sodium hydroxide, etc., soon destroy it. The diluted or weaker alkalis have a less harmful effect on the enamel, and with many of the weaker solutions the enamel will last for a considerable length of time.

It is claimed that the enamel will withstand inorganic acids, such as nitric (sp.gr. 1.25), sulphuric (sp.gr. 1.2), hydrochloric (sp.gr. 1.1), for a normal length of time (immersion for 48 hr.) without injury.

A solution of 10 per cent alcoholic potash will remove the enamel in 30 to 45 min.

Enameled wire will stand a high heat longer than cotton-covered wire, or 100 deg. C. (212 deg. F.) continuously, and due to the higher heat conductivity of the enamel, the dimensions of magnet coils can be decreased.

In general the following are the advantages of enameled wire: A dielectric strength of 600 volts per mil thickness; elasticity of the coating permitting bending around small radii without cracking or peeling; a film that is as hard as consistent with elasticity, to withstand abrasion; close adhesion of the enamel under wire tension; non-ageing or little affected by continued heating and cooling; ability to withstand temperatures that would spoil cotton covering. A high grade of enameled wire will withstand 149 deg. C. (302 deg. F.) without harm. A better space factor for all classes of windings and better heat radiating properties for magnet and field coils, and a lower over-all cost per pound, are other advantages that accrue from the use of enameled wire.

From the data given above, a study of the conditions of manufacturing and operating will determine whether enameled wire will prove satisfactory for a given winding.

In general, starting windings of single-phase motors, fan motor windings, for both direct and alternating current, and direct-current armatures for motors up to ¼-hp., including drills, etc., can be wound with enameled wire.

Table V gives the weights, lengths, etc., of enamel-covered wire. A stock of the sizes from No. 19 to No. 30 inclusive, will be found to cover most repair jobs.

The properties and characteristics of cotton insulation will be discussed in the next article.

Organization of Industrial Plant Fire Departments

By A. A. BECKWORTH
Director, Technical and Industrial Research Division, The Sherman Corp., New York, N. Y.

FIRE-FIGHTING apparatus will be found in nearly every industrial plant, but the advantages of having this equipment at hand are nullified if a corps of trained men has not been established for using such apparatus efficiently in case of emergency. The statement is generally made that the first 5 min. of a fire are more important than the next 5 hr. Attempts have been made in many cases to organize fire brigades, which have been allowed to struggle along for a short while, and then interest has dropped to the point where these brigades are no longer of sufficient value to act as a real protection to the plant. The following outline indicates suitable organization plans for fire brigades in industrial establishments of various sizes.

Unless the plant is very large or unusually hazardous materials are used in the processes, the usual plan is to organize fire brigades from among the working personnel in the plant. The efficiency of such brigades will depend largely on the care with which the members are chosen. Intelligent, loyal, and constructive-minded individuals should be selected who are alert and physically able to undertake the duties involved. Sometimes it is advisable to give preference to men who live comparatively near to the plant, or within hearing distance of the general fire alarm. Where a plant operates more than one shift, brigades should be formed with men from each shift.

Fire brigade members should, of course, be able to speak and understand English, and should be thoroughly familiar with the general layout of the plant and with the various operations performed. Thorough knowledge of stairway locations, elevator shafts, hazardous places, and the nearest fire-fighting apparatus, must be possessed by every brigade member, in order to prevent confusion, or accidents.

With proper constructive education, membership on the fire brigade can be made to be deemed a privilege by the employees. In addition to a badge, brigade members should be provided with passes that will enable them to secure admittance to the plant in case of fire outside of working hours. It is sometimes advisable to add an incentive in the form of a small bonus paid quarterly or semi-annually. In addition, the brigade members should receive their regular rate of pay while on fire drill or duty.

Strict discipline should be maintained among the brigade members,

and failure to report for practice at fire drills, or in case of fire, should involve some fine for the delinquent members. In cases where a bonus is allowed, the record of attendance at drills should be kept and the members penalized for their failure to maintain perfect records. Such fines can be placed in a special fund and used either for purchasing additional equipment, or for entertainment features.

For plants of fairly large size the following general plan of organization is suggested: Fire Chief, Assistant Chief, Company or Floor Captains, Company or Floor Lieutenants, and Brigade Members.

For medium-sized plants, the Assistant Chief may not be needed, while for small plants the officers in the brigade can be the Fire Chief and Company Captains. In addition to the foregoing members of the brigade, it is advisable to have in each organization one or more employees of the Plant Maintenance Department, who are familiar with the plant piping systems and with the operation of all valves. An electrician who has a thorough knowledge of the distribution system in the plant should also be a member of the brigade. These special men should respond to all alarms and be subject to the orders of the Chief or Assistant Chief.

The duties of the Fire Chief are such that they require a man of outstanding caliber and integrity for this position. Some times it is advisable to choose a man who has had previous experience in fire department work, to devote all of his time to the development and training of a brigade. In other cases, or in smaller plants, either the Master Mechanic or foreman of some important department should be chosen for this office. It is necessary for the Chief to have the respect and obedience of the men under him at all times.

The Assistant Fire Chief will act as the aid to the Chief, and closely superintend the training and development of the entire department. When more than one shift is working, the Assistant Chief usually takes care of one shift, but at all times, he is subject to the orders of the Fire Chief. In a medium-sized plant, the Senior Captain may act as Assistant Chief.

The Company or Floor Captains are important officers in the brigade organization. Where the plant is divided into various sections, the Captain is in charge of his particular section; in cases where a plant occupies several floors in a building, it is advisable to have a Captain for each floor. Too much care cannot be exercised in selecting the proper men for Captains. These officials should be workers who are known to be constructive and loyal, and who hold the respect and obedience of the men. Often it is advisable to choose foremen or assistant foremen to fill these positions. Captains should be graded according to seniority and efficiency; they take charge of the brigade in case of the absence of the higher officers.

The Company or Floor Lieutenants are direct assistants to the Captain, and the Senior Lieutenant takes charge of the Company in the absence of the Captain. Brigade members who have shown efficiency in service in the ranks should be promoted to be Lieutenants, and on up through the staff as vacancies occur.

As a general rule, the fire-fighting organization should be arranged so as to utilize the special knowledge and experience of the members. For this purpose, a brigade should consist of several companies, each of which is delegated to handle special kinds of apparatus, and to attend to specific duties in case of fire. Of course, in a very small plant, the brigade companies are usually all-round firemen, but in larger plants, specialization is recommended. Among the special companies to be organized are: Hose Company, Hook and Ladder Company, Chemical Engine Company, Standpipe Company, Hand Extinguisher Company, Pump Men, Special Men and Salvage Corps.

Hose companies should be made up of not less than ten men, including the Captain and Lieutenant. One man should be assigned to hydrant duty, and at least four men for each line of hose operated. Not more than two lines of hose should be assigned to a company. Where only one line of hose is to be operated, the company can be made up of only five men.

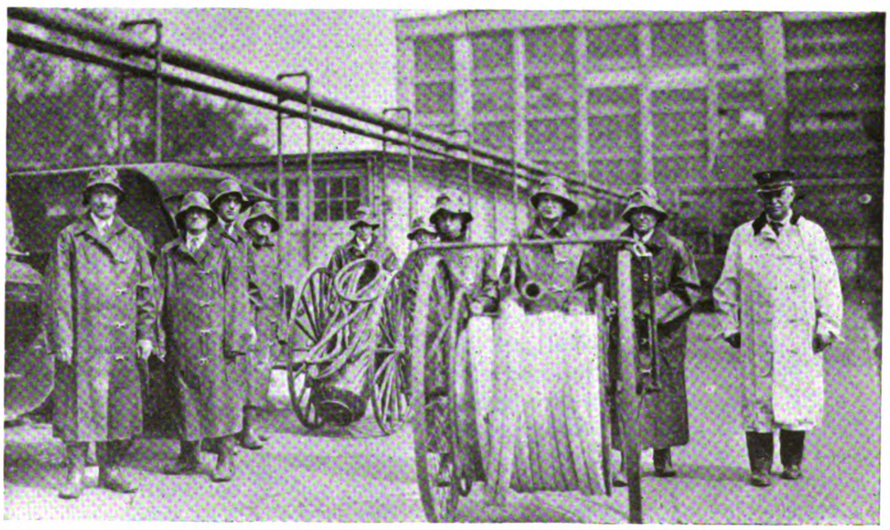
The Hook and Ladder Company should be made up of not less than nine men, including the Captain and Lieutenants. The exact number will depend on the type of building, exposure, and character of operations. The Hook and Ladder Company attends to the placing of ladders, handling and use of chemical extinguishers from trucks, opening of roofs, floors and partitions, wrecking, and such other fire duties as are necessary in the judgment of the Chief.

The members of the Chemical Engine Company are usually six in number, including the Captain and Lieutenant, and they have charge of operating the engine tank, adjusting and manipulating the valves, and recharging. They should be held responsible for keeping the tank fully charged and ready for service at all times.

In plants equipped with an interior standpipe system, a separate Standpipe Company should be organized to handle the hose lines connected therewith. A sufficient number of members, usually not less than

Part of the fire brigade at Bausch & Lomb Optical Company, Rochester, N. Y.

The complete brigade consists of a Chief, two Assistant Chiefs and 29 men, who are grouped into two hose companies, two chemical companies and a salvage corps. The men are provided with rubber hats, coats and boots. The Chief was formerly a captain with the city fire department. This illustration is by courtesy of Foamite-Childs Corp., Utica, N. Y.



six, should be chosen so that at least four men will be available for each of the interior hose lines. In each squad, there should be a valve man whose duties are to remain at the valve to turn the water on and off, and to assist in unreeling the hose line. Where standpipe systems are supplied from gravity tanks or by means of connections with city water mains, there should be a main valve man who is responsible for seeing that the valve between the source of supply and the standpipe system is open or shut as directed by the officer in charge.

The members of the Hand Extinguisher Companies must know the most effective methods for bringing into use the various types of extinguishers provided in the plant. They should know how to handle each type of extinguisher properly, although any worker is permitted to use an extinguisher within his reach as soon as a fire occurs in his immediate vicinity. Where the plant fire system is supplied by local fire pumps, it is advisable that the engineer and his assistant be enrolled in the fire brigade so that they will be able to assure the proper working of the pump in case of fire.

In plants where valuable stock or machinery is likely to be damaged by water, a company of men under the direction of a Captain and Lieutenant should be organized into a Salvage Corps. These men should be instructed in the best methods of covering up stock and machinery, and for saving valuable records. In some cases, suitable equipment such as rubber or fireproof blankets should be provided for the Salvage Corps, and located in a convenient place.

The exact nature of the equipment used by the fire brigades will depend on the size of the plant, but in every case all equipment should be kept in first-class order at all times, and centrally located. Protective clothing for the brigade members is also desirable, and such clothing should be kept in the proper location when not in use. Care must be taken to see that some of the members do not take such equipment home and fail to return it promptly. Gas masks and similar equipment are often provided to cope with special problems that pertain to the individual plant.

The success of any fire-fighting organization depends on the promptness with which the brigade companies report and their efficiency in handling the equipment. Such efficiency can be developed only through frequent and thorough fire drills.

It is best to hold drills at unexpected times, and announce them by sounding the usual fire alarm. These drills should be thorough and serious, and every individual in the fire brigade as well as throughout the whole plant should respond immediately, just as though there actually were a fire. The members of the various companies should go through their duties completely.

When the fire drills are first held, there will be confusion and duplication of effort. However, the Fire Chief and his Assistants should soon be able to straighten out matters and to delegate definite performances to each group. The Fire Chief should be directly responsible for all inspections, both of the plant and fire-alarm systems.

Fire extinguishers should be kept fully charged, and all fire doors, and so on, should be maintained in first-class order. The employees in the various departments must be instructed as to their actions in case of a fire alarm, and the Captains and Lieutenant in charge of the department must see that these rules are strictly obeyed. Usually the Captain will delegate an individual to inspect all washrooms and lavatories when an alarm is sounded, in order that every employee may be duly warned of the danger.

An example of a suitable fire alarm bulletin notice to all employees is given in the accompanying box. Employees should have occasional fire drills also so that they will know what to do when the occasion demands.

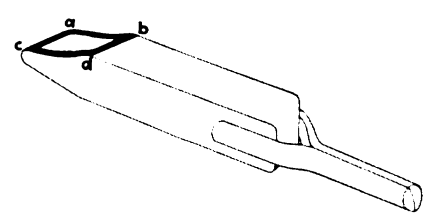
When the Fire Alarm Sounds All Workers Must:

Stop work.
Shut off power.
Stop machines.
Shut off gas and other open flames.
Close doors and windows opening upon or under fire escapes.
Put chairs, stools and other obstructions on top or under benches to clear the passageways.
Form line promptly with front of column facing the usual exit and wait for word of command from Floor Captain.
At the command to march, march in an orderly manner from the building, two abreast, not crowding upon the couple in front, and following the aisle leaders.
Preserve the space in lines between yourself and the couple in front of you.
Retain formation until dismissed or until the line is returned to building.
Don't run.
Don't lag behind, breaking up columns.
Don't scream or make unnecessary noise.
Don't laugh or talk.
Don't cause confusion.
Don't remain in toilet or dressing rooms.
Don't return for your clothing.
Don't try to use elevators.
Don't try to leave the building except in accordance with fire regulations.
Don't fail to assist in carrying out instructions.

Simple Method of Soldering Overhead Work

OCCASIONALLY it is necessary to solder overhead seams and do other work of this sort, and unless the mechanic has previously learned how, he is likely to find difficulty in preventing the solder from running off the hot copper. The operation may be performed by taking an ordinary soldering copper and forging or filing it to the shape shown in the accompanying illustration; it will be noted that there is a slight curvature of the tip between *a-b* and *c-d*.

The copper should be filed smooth on the curved surface and tinned in the usual manner. By touching the edge of the hot copper to a piece of rubber—an ordinary pencil eraser will answer—a narrow ridge of rubber may be built up on the edges.



Soldering copper for use on overhead work.

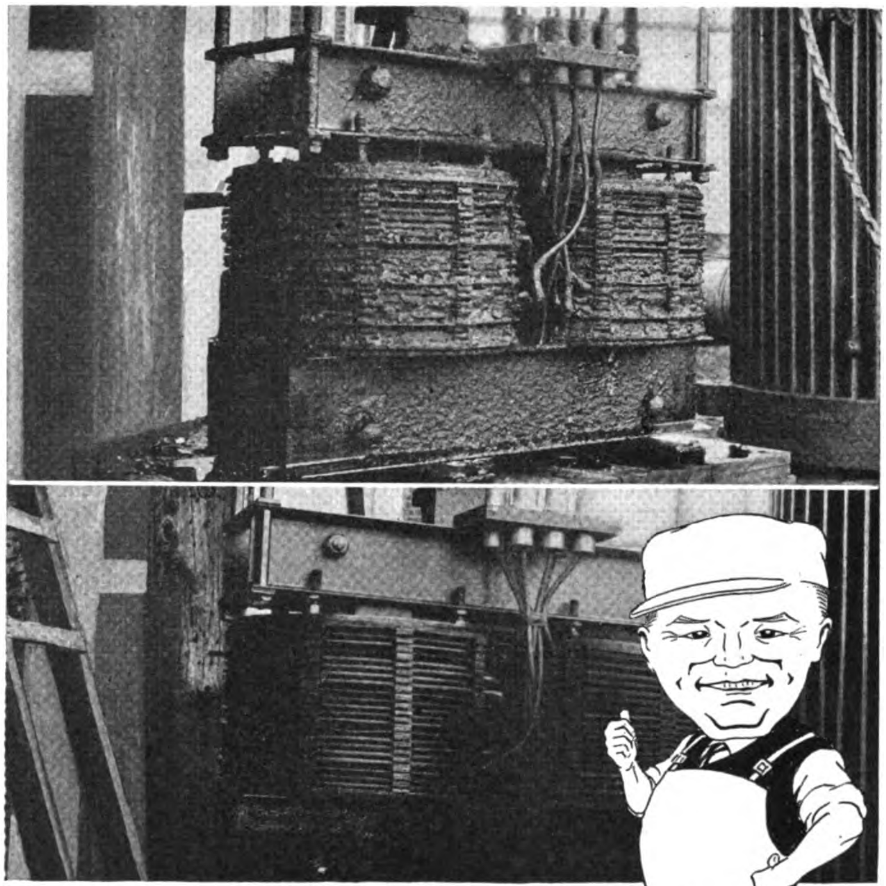
By filing a soldering copper as shown, and building up a ridge *a-b-c-d* by touching the hot copper to rubber, molten solder may be held up against an overhead seam or other work to be soldered.

This ridge border is indicated by the heavy line in the illustration. This border should be completely carried around between points *a*, *b*, *c* and *d*. The molten solder will then be prevented from running off when the copper is lifted overhead and soldering may be carried out successfully.

New York, N. Y. R. C. NASON.

Dirt Always Makes Trouble

and when it gets inside of a transformer case will cause overheating



NOT long ago I called on an old friend who has long been associated with one of the largest industrial plants in a well-known southern city. He is an old-timer in operating and maintaining plant equipment, and has acquired a wealth of practical information for which I have a wholesome respect. While sitting in the shade of a bank of high-line transformers, we threshed out some of the problems that every operating man has to solve.

"Long ago," he said, "I came to the conclusion that most of the trouble we operating men have, we bring on ourselves. For one thing, we abuse equipment and neglect it. Furthermore, probably every piece of equipment gives us plenty of warning signs that trouble is brewing, but we are sometimes too careless to notice these signs.

"I have been guilty more than once of doing these very things. The last time it happened was in connection with these transformers. A transformer does its work without making much noise or fuss, even when it is neglected. Nevertheless, it requires a certain amount of attention and when it does not receive this attention, it shows certain symptoms that every operating man should be familiar with. One of these signs is overheating at less than full load.

"For nearly a year the temperature on these transformers had been gradually increasing and we could find no evidence of increasing load. Finally the temperature reached 85 deg. C. at only 80 per cent load, which is the maximum permissible top oil temperature for self-cooled, oil-insulated transformers. We decided to take one of the transformers apart, clean it, and see if we could find anything wrong. These transformers are rated at 600 kva. apiece, and step our power down from 13,200 volts to 440 volts; so you can see that we had a real job on our hands.

"First, the oil was drained off and then the cover removed from the case and the coils and core taken out by means of a chain fall. The coils were found to be in the condition shown in the top picture. One glance was enough to tell us that this accumulation of dirt and sludge was causing our trouble.

"We scraped off as much of the dirt as we could, filtered the oil and then forced clean oil under pressure through the parts of the transformer that could not be reached with a brush or scraper. When we were through cleaning the transformer, I took the picture shown in the bottom illustration.

"Just as we expected, the operating temperature was found to be only 45 deg. C., with an 80 per cent load. This was nearly normal. As soon as possible we cleaned the other transformers in the same way, and have had no more trouble with them.

"Cleaning transformers in this manner is not a regular procedure, and you may tell the other readers of INDUSTRIAL ENGINEER that if their transformers show a tendency to overheat while underloaded, it is a pretty sure sign that they need to be thoroughly cleaned out."

As my old friend says, abuse, neglect, and failure to recognize or properly diagnose the signs that equipment in distress always gives out, account for most of the troubles that operators have to contend with. When you find a plant in which breakdowns of equipment are seldom heard of (and there are many such plants) you may be pretty sure that watching that equipment is a skilled operator whose eye and ear and hand are trained to detect the faintest sign of trouble.

Sometimes those early signs of trouble are hard to detect and may be still harder to interpret. Probably many of you have had some interesting experiences along this line. If so, send me the details and we will start what the doctors call a clinic and discuss some of those cases.

Practical Pete

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

G. A. VAN BRUNT, *Managing Editor*

The Genius of Charles A. Coffin Will Live Long in the Electrical Industry

WHEN Charles A. Coffin, founder of the General Electric Company and long its president, passed away a few days ago, the electrical industry lost one of its most forceful and talented leaders.

Mr. Coffin was not an inventor, but he was a human dynamo in the business and financial sides of electrical development. He invented methods of business for an industry that was in its beginnings when he came into it. And in this process he displayed a depth of originality and imagination that is usually attributed to artists, inventors, and great engineers. He was a master of finance and succeeded well in undertakings in which most other men would probably have failed. He used the same methods, exercised the same imagination, the same inventive power and the same rare vision in the field of finance that Edison has shown in the field of applied science and engineering.

Mr. Coffin was a master organizer. His great work was, of course, the building up, from many component parts, of a far-flung electrical organization in which he was the guiding spirit as well as its chief inspiration. It was his attractive personality and proven capacity as a great leader in the industry that brought about, in 1892, the formation of the General Electric Company by the consolidation of the Thomson-Houston Company with the Edison General Electric Company. By this amalgamation of interests, the difficulties of a complicated patent situation were largely reduced, which ultimately gave to the electrical industry for the first time stability and the opportunity for development on sound lines.

Mr. Coffin has left the stamp of his genius on the electrical industry. His death brings to an end a career of achievements of which any man might well be proud. His services to science, progress, and industrial efficiency will be remembered as long as the industry which he helped to create survives.

Without Records of Past Performance It Is Impossible to Measure Progress

FROM his first experience in industrial plants, every operating man is continually impressed with the necessity of securing uninterrupted operation. Practically his entire time is directed toward the prevention of something which might cause a breakdown, or in getting the equipment back into service afterward.

Comparatively few such men, however, know how well they are progressing toward the achievement of their aim—continuous operation—because they keep no usable records of what they are doing. Keeping a number of cumulative records takes time and many operating executives do not have much office assistance.

There are two records, however, which any man who desires to show regular improvement in his results should keep. These are cumulative and periodic records of man-hours in his department and also the hours-out-of-service of the machines for which he is responsible. The first of these, should, of course, take into account extensive new construction and variations in production in order to make the tabulations comparable. Such records, if kept up regularly, will not require much time to maintain, and the few minutes spent in studying them as the notations are entered will be well invested.

It is advisable to have such records plotted in the form of curves for ready reference and for ease in comparing data taken at different times. Use of such charts will be a big help in showing a plant man how well he is doing his job and the progress he is making.

Money Kept in the Bank Will Not Cut Production Costs in the Plant

HAVING to report that a $50,000 installation of new equipment which you recommended is not producing the expected results, is a job that the most stout-hearted might well dislike. When the Plant Engineer of a well-known industrial organization was forced to make such a report some time ago, his superior merely said, "Yes, I know you are sorry, and you need not take the time to explain just why it doesn't work properly. Go ahead and do whatever is necessary to make it right."

It turned out that a slight rearrangement of the equipment, with the expenditure of a comparatively small sum for additional devices, was all that was needed to make the installation perform even better than had been expected.

The attitude that was shown in this present instance is typical of this organization. The management has always not only placed complete confidence in the engineering and operating executives, until conclusive evidence has been given that this confidence was not merited, but it has likewise been willing to make any expenditures that could reasonably be expected to reduce operating and production costs. If it can be shown that an investment will produce a 4 per cent return, the expenditure is approved without argument. The executive who has proposed the change is then given every chance to make his project a success. Even in the face of apparent failure, his efforts are viewed with a sympathetic understanding that cannot help bringing out the best that is in him and, in the long run, seldom fails to produce the desired results.

In consequence of this far-sighted attitude, the men are encouraged to submit their ideas for consideration, with the result that many good plans are put into operation every year. The combined effect of all of these

betterments has been to place this company in such a dominant position that the management does not have to worry about rising labor costs or price competition.

A penny-pinching attitude toward expenditures for needed equipment, or anything else that will improve operating conditions, may serve to keep down the capital invested, but it will never help any plant to make a reputation for efficiency of operation.

Do You Welcome the Exchange of Operating Experiences?

A CONTRIBUTOR to INDUSTRIAL ENGINEER, in some correspondence regarding an article in which he discussed the solution of a difficult operating problem, recently made the following interesting statement:

> It has been my experience that the average operating industrial engineer is altogether too reticent concerning problems which he encounters in his work, and in his solution of them. Much must be done by these men toward improving operating conditions and reducing production costs. The dissemination of the solution of more of the problems met in the everyday activities of industrial engineers will tend to aid other men with similar responsibilities in obtaining a broader viewpoint and the equivalent of a practical experience in such problems without many of the disheartening features connected with the school of hard knocks.

This man not only visits other industrial plants to pick up new ideas, but welcomes other men to his plant, as he knows that they have had experiences which may be new to him. His ability to build up his own experience by seeking additional information from others is, no doubt, responsible for a good deal of his success in fitting himself for the promotions he has had.

The pages of INDUSTRIAL ENGINEER are open for the discussion of operating problems and ways of solving them. The arrangement of the editorial pages into articles and departments makes it possible to discuss simple as well as more complicated problems and other topics that are of interest to the operating executive in industrial plants. Now is a good time for those who have been receiving the benefit of the experiences of others through these pages to contribute some of their own experiences.

Unsafe Protecting Devices Are Often Worse Than None at All

MANY times auxiliary equipment, which is not a part of the operating mechanism and so is not absolutely essential to its continued use, is neglected because of the feeling that "it does not have to be fixed right away." Safeguards of all kinds, and fire-fighting equipment, in particular, are often neglected for this reason.

A safeguard is put on a machine for the purpose of protecting from injury the operator or anyone who comes too close to the working parts. A guard which does not function is of no more value than no guard at all. In many instances, such a guard is an extra hazard in that, due to its presence, the operator may rely upon it and at the critical moment find it ineffective and so suffer injury.

Fire-fighting apparatus is another type of equipment, the presence of which implies its availability for instant service. Altogether too often, the empty extinguishers or the battered thread on the hose couplings are not discovered until an emergency arises, when their worthlessness may be responsible for a serious loss.

Much of the responsibility for seeing that safeguards and fire-fighting equipment is always in operating condition rests on the men in the maintenance and operating departments. They should realize that they are not through with repairing a machine until the safeguards are replaced and adjusted. Also, that their duty has not been discharged until every fire extinguisher has been refilled and replaced, after use.

No guard to life nor property is of any value unless it is capable of rendering 100 per cent service.

Are You Getting All You Should From Your Arc Welding Equipment?

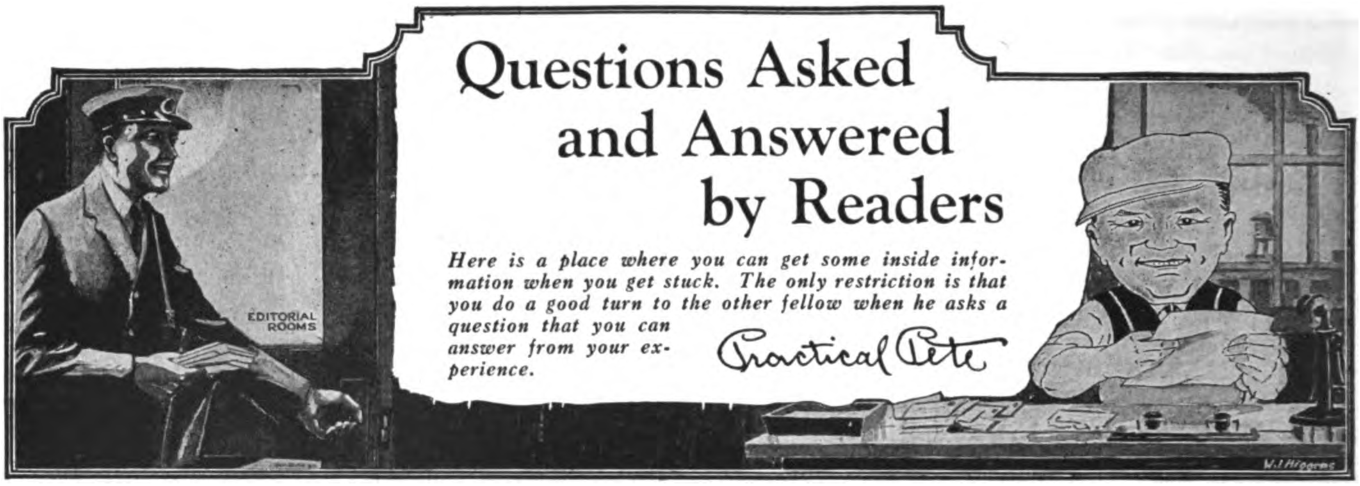
ARC WELDING has been with us for a number of years and has received recognition in many industrial plants as a means of repairing broken parts. However, one may well wonder if it is getting the recognition that it deserves. Are you getting all that you should from your arc welding equipment?

Arc welding equipment is an Aladdin-like glue pot, so to speak, which furnishes us with a means of sticking pieces of metal together much as though they were paper. This means that not only can broken parts be stuck together, but new parts can be manufactured. In most cases these new parts will be made from steel instead of cast iron. The result is that standard steel shapes obtainable in any steel warehouse can be cut and welded together to fabricate much of the shop equipment, such as benches, put up small buildings, repair old machine parts, or make new ones, and so on.

A rough pencil sketch of what is desired is all the instruction that an experienced welder needs to have in order to make a very serviceable and rugged job from welded steel members. This eliminates the draftsman, the pattern maker and the foundry; it cuts down the storage of patterns and the inventory of cast-iron parts. A job that would ordinarily take days now becomes a matter of minutes. The resultant saving in time, money and reduced delay to production is worth much consideration.

Arc welding is long past the experimental stage; it has reached the point where progressive plant executives are not only using it as a means of making large reductions in repair and maintenance costs, but also in cutting costs of installation and erection. Many plants are using it in regular production with large savings in time and money.

If you have not already done so, it will pay you to investigate thoroughly the savings in time, material and money that are possible by the use of arc welding.



Who Can Answer These?

Bearings in Wet Locations—It is necessary to operate one of the bearings of a washing device under water. We have not been able to lubricate this bearing and have had considerable trouble due to extensive wear from lack of lubrication and dirt in the water. Babbitted bearings have always been used but I should like to learn the experience of readers with other types of bearings operating under conditions somewhat similar to this. Perhaps someone can suggest a lubricant or method of application which will work. I shall greatly appreciate any information that readers may give.
Des Moines, Iowa. L. D.

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Operation of Electric Refrigerator—Would there be any objection to using brass valves, pipes and fittings, instead of copper, between the compressor and cooling coils of a small electric refrigerator, similar to a household unit, that uses sulphur dioxide as the refrigerating medium? What material is best suited for use as packing and gaskets? What kind of lubricating oil is best adapted for the compressor? What pressures should be carried on the intake and on the discharge when the compressor is running, and when it is not running? What is the best method of charging a unit of this size? I shall be very grateful for any information that readers can give me on these questions.
Oak, Neb. H. L. M.

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Changing Speed of Induction Motor—I have a 10-hp., 1,200-r.p.m., 220-volt, three-phase, 60-cycle, Westinghouse squirrel-cage induction motor that has 54 slots and 54 coils having a span of 1-and-8. Each coil is composed of 15 turns of two No. 16 d.c.c. wires in parallel. The winding is six-pole and is connected two-circuit star. I wish to reconnect this winding so as to have the motor develop 10 hp. at 1,800 r.p.m., when used on the same supply as before. Can some of the readers tell me how to reconnect the motor to obtain this result?
Chicago, Ill. C. R.

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Trouble with Storage Battery Charging Generator—We are having considerable trouble due to the reversal of polarity on a 50-kw., 120-volt, interpole generator which is used to charge storage batteries on vehicles. The machines were tested for grounds by means of a Megger and a heavy leakage to ground through the acid-soaked benches in the battery charging department was discovered. Having remedied this, the generator was started and immediately the voltmeter read backwards with no load on the machine. We checked the leads from the machine, but they were of such size and so taped together that it would be impossible to reverse them by mistake. We tried to re-excite the field, but could not; so the leads were reconnected so as to reverse them at the generator and not disturb anything at the switchboard. The generator worked satisfactorily for about three days, when the polarity again reversed itself. We reversed the generator leads to their original position and since then the machine has been operating satisfactorily. I do not know what caused this reversal of polarity and should like to have readers give me their suggestions.
Sacramento, Calif. J. T.

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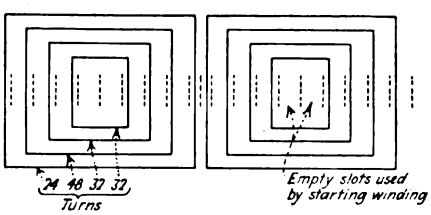
Method of Determining Chord Factor—I shall appreciate receiving any information from readers concerning satisfactory methods of finding the chord factor for the following winding. The winding is on the stator of a ½-hp., 110-volt, 60-



cycle, single-phase induction motor. The stator has 36 slots and four poles and is arranged with a starting winding. The main winding is connected as a whole coil, concentric, as is shown in the accompanying diagram, which shows two pole groups.
Milwaukee, Wis. J. M.

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Grouping of Wires in Conduit for Two-Phase System—I have installed some 3-in. conduit runs, to be used for two-phase power supply circuits. These conduit runs are about 25 ft. long. In them I wish to place 500,000-circ. mil. cables and since it is possible to get only three cables of such size in a 3-in. conduit, it will be necessary to group the cables in two conduits. Will it be satisfactory to place the two A-phase cables in one conduit and the two B-phase cables in the other? In a three-phase system, this should not be done; hence, I am doubtful about doing it with two-phase cables. Would it be preferable to place one A-phase cable and one B-phase cable in each conduit? If so, which of the two B-phase cables should be placed in one conduit with the first A-phase cable? Please give me some information on these points.
St. Lambert, Quebec, Can. J. M.

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Will This Generator Operate Satisfactorily at Increased Speed?—We have a Westinghouse, Type C, 50-hp., alternating-current motor having a full-load speed of 850 r.p.m., which we plan to use in driving a General Electric direct-current 55-hp. 725-r.p.m. 110-volt generator. We would like to couple these two units directly together instead of making a belt-driven unit. This would necessitate running the 725-r.p.m. generator at a speed of 850 r.p.m., or an increase of 17 per cent in speed. I should like to learn from readers whether or not this generator will operate satisfactorily at this speed, and also whether the increased voltage delivered by the generator can be reduced in any way so as to obtain the original voltage generated at 725 r.p.m.
Hartford, Conn. H. V. D.

Answers Received To Questions Asked

Method of Checking Bearing Alignment.—I should like to know how to check the alignment of bearings on machines having three or more bearings supporting the same shaft, or where two shafts are coupled together by means of rigid couplings. An example of this is a three-bearing, motor-generator set or a large, heavy-duty motor or pump having a pedestal bearing in addition to two regular bearings. I shall appreciate any suggestions that readers can give me for doing this work.
Chicago, Ill. F. B.

The problem of F. B. in the alignment of relatively short shafts is considerably different from the alignment of long coupled shafts, such as line-shafts. Usually, the parts of such machines as F. B. has in mind which are available for lining up are very short, and often the shafts are completely hidden beneath couplings.

In the case of a motor-generator set, about the only place to do the aligning is on the couplings. If these cannot be removed except at great expense, the tests must be made on the peripheries and between their opposing faces. Such tests presuppose that the faces and rims of the couplings are true with the axes of their respective shafts; if they are not, they must be turned or ground true before the tests are of any value. Couplings may have been machined concentric with their bores but the commercial allowance on bores and on shaft sizes may be such that the insertion of the driving key will pull them considerably off-center by the time a check is made at the outer surface.

Alignment of shafts can be checked on flange couplings that are true and of the same diameter by the use of a steel rule and paper feeler or thickness gage. It is first necessary, however, to remove the bolts which fasten the flanges together. The rule is placed successively at the top and bottom and at the two sides of the couplings. While resting the edge of the rule on one-half of the coupling, a paper feeler is used between the far edge of the rule and the other half of the coupling. If the paper is tight at all four points it is safe to assume that the shafts are in line, after having made a check test by turning the machines over one-half revolution. A further check is made by applying the feeler between the flat

faces of the couplings at the same four points.

With flexible couplings, the space between the two halves may be more than the range of the common mechanic's thickness gage and it must be supplemented by a block that nearly fills the space, or such a block may be filed to an approximate fit and used with a piece of paper as a feeler.

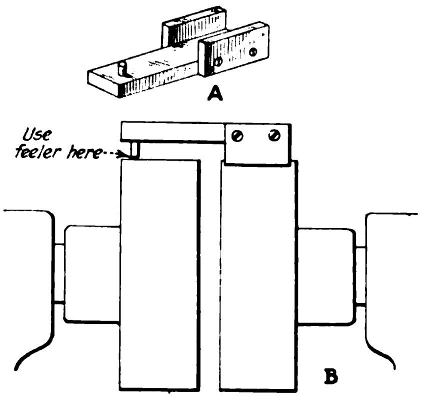
Such a test as described does not level up the machines and this point must be taken up separately. When a set is factory-built and the two units are mounted on a common base, the latter can be leveled up and there is every assurance that the machine is practically level. On small machines of this type, it is sometimes possible to drop a line from the outer shaft ends to the base and to do the same thing on the stub shafts in the center, just back of the couplings, and then to compare these with a line scribed on the base (or a straight-edge) which is used as a datum line.

Couplings are seldom perfectly true and of the same diameter. In that case a simple tool for lining may be constructed, as shown in illustration *A*, by attaching two pieces of flat iron to a piece of cold-drawn steel and putting a short pin in the outer end. A similar tool may be machined out of a solid block of steel, iron, or brass. The reason for making the tool of this general shape is to form a V-block which will keep itself parallel to the axis when placed on a shaft or other round part. The difficulty of doing this with a piece having a single bearing line, such as a rule, is the chief objection to the first test, as described above. With the concave or V-block, this difficulty is overcome. The method of using this block is shown at *B*. Such a tool is cheap to make and very useful on jobs of this kind; it is equally useful on couplings and shafts and it can be made in any length suitable for the work in a particular plant.

All machines should be leveled up. When a set is mounted on a common base, or bedplate, there is always a chance to do the leveling on a planed upper surface of this. Otherwise, one has to clear the shaft of couplings or pulleys and level up by it. It is sometimes possible to provide a foundation sufficiently level so that other checking is not necessary. When a truly level plane has been established in one of the ways named, the only deviation from this will come from wear in the bearings.

On motor-generator sets where the shaft length is above the average, the foregoing check at the couplings does not line up the machines closely enough. It is obviously poor practice to line up a 10-ft. shaft on the periphery of a coupling whose radius is only 7 or 8 in.

Illustration *C* shows a more accurate method of lining from a coupling. The device used consists of two pieces of light steel angles which have one leg of each bent at right angles to form a foot which is attached to the rim of the coupling by two screws. These angles can be any length that will swing without touching the floor or bedplate; long angles will permit making a more accurate check because it is further from the center. Angles are

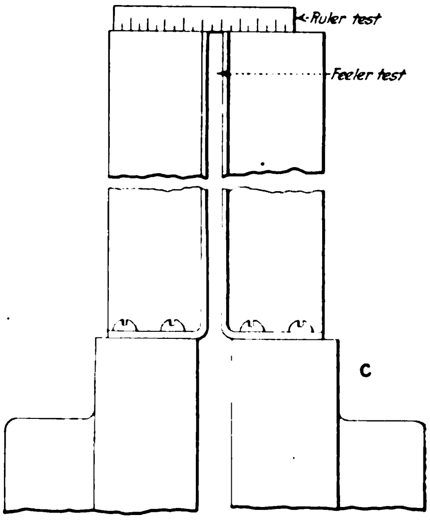


This simple gage, A, is used with a feeler as at B for checking alignment of short shafts at the rim of couplings.

light, stiff, and cheap; an hour's work will put these in place and the accuracy of alignment which may be obtained makes them worth more than this slight effort. Also, the angle irons may be kept and used on other couplings and also for periodic checking of the alignment.

If the angles are made the same length, the ends should be squared off so that the test with a steel rule can be made at four points of revolution approximately 90 deg. apart. If one angle is made longer than the other, or the two flanges are not of the same diameter, scriber marks can be made on the longer one and the machines will have to be shifted until these marks made at opposite points finally coincide. The other check to be made with these angles is by use of a feeler between them. This test should also be made every 90 deg. These same tests may be applied to solid flange couplings, although it would be necessary to loosen or remove the bolts which hold them together.

It might seem that undue emphasis has been placed upon the apparently simple test of checking up at the four 90-deg. points, as indicated in the above paragraphs. However, with electrical machinery, all that there is to work



Where the shafts are over 10 ft. long this type of gage is used at the couplings to check alignment.

with in most cases is the coupling and it is an impossibility for two shafts to have these several checks come out right unless the shafts are in line. Hence the method forms a check especially adaptable to such jobs.

For machines having an outboard bearing, it is essential that the shaft be true and its truth known for a certainty. If there is a worn spot inside a bearing or a bend in the shaft, however, all the painstaking labor of lining up will be in vain.

Where it is known that the shafts are perfectly straight and have no worn spots inside the bearings, one of the easiest ways to check alignment of the bearings is to secure a length of shafting of the same diameter and try this in the three bearings, which presumably are of the split type, divided horizontally. With the caps off, a level (having a grooved base) is used at several points to determine the straightness of the shaft as it lies in the cradles formed by the three half-boxes.

The following method of checking against bent shafts assumes that some of the previously mentioned tests for alignment of bearings have been made. Bent shafts are difficult to detect on motor-generator sets and other types of machines with three bearings because of the armatures, rotors, or other parts which are mounted on the shaft. One of the easiest ways to check up a bent shaft in such cases is to secure a length of straight shafting of the same diameter and try this in the three bearings as described above.

The foregoing is one of the easiest ways to check up a bent shaft, either the machine shaft or the length of shafting used for trial purposes. A bend in the piece of shafting will be plainly visible and readily caught if the level be tried on it at one or more points, trying it first "as is" and then trying it as turned over 180 deg. Assuming that it has been found to be straight by this test and the bearings have been scraped or lined up to it, the real machine shaft should lie in the half bearings in the same way and a check with slips of paper or the use of a little spotting material rubbed on the journals would quickly show if there were any bend in this piece.

This special piece of shafting can also be used to spot up the bearings, in the same manner as when bearings are being scraped in. The outboard bearing is shifted, however, instead of being scraped in. If it is possible to turn the machine over (rotate the shaft), its own shaft may be used in much the same way for spotting as a means of determining alignment; where the journals are of two or more diameters, this will have to be done.

Strips of paper laid under the shaft, when it is raised, will also show a high or low bearing. A strip of paper at each side of the shaft at each bearing will show lack of alignment sideways. These strips should extend in an inch or two between the shaft and its bearing and be pulled after the shaft is lowered again. The necessary adjustments may then be made and these tests repeated until the alignment is perfect.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Armature Bands Overheat. — Five bands are used on a 220-volt, d. c. armature with which we are having trouble. The armature coils slope very sharply and to prevent the outside bands from slipping off the ends of the armature, the winder soldered copper strips across the bands so as to tie them together. Six [illegible]-in. strips were placed parallel to the coils and spaced at equal distances around the armature. The bands as well as the copper strips are well insulated from the armature winding, but the bands and particularly the copper strips become very hot, presumably from some induced current. I would like to know what causes this heating and how it may be prevented. If it is induced current that causes the heating please explain what causes this current. Is there any way in which I can tie these bands together that will not cause the heating referred to?
Oelwein, Ia. L. T. M.

Answering L. T. M.'s question, the copper strips parallel with the slots are conductors moving in live fields, so that when they are shorted by the armature bands, they act just like the main conductors in the armature, and have current generated in them. This often happens when wide bands are soldered into one sheet band. If L. T. M. will replace these copper strips with steel strips, which have eight times as much resistance, he can likely cut down the current flow enough to prevent heating. W. MONTELIUS PRICE.
Seattle, Wash.

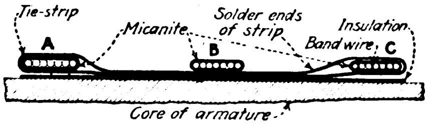
* * * *

If L. T. M. had stated the size of the armature with which he is experiencing trouble from hot armature bands, and had also given the width of the individual bands, it would be possible to give him more definite information.

The heating of the bands, however, is caused by eddy currents generated in them by the constantly changing magnetic flux through the armature conductors. This flux cuts through the bands and is constantly changing from zero to maximum in one direction, back to zero, and up to maximum in the opposite direction as the armature rotates.

L. T. M. states that all five bands on this armature have been electrically as well as mechanically tied together. This, no doubt, is the cause of the excessive heating of which he complains. These bands are probably each narrow enough so that if they were not connected together, they would not overheat any more than is common with this portion of an armature. It seems to be necessary to tie these bands together to prevent the outer ones from slipping off the armature.

I would advise L. T. M. to insulate the tie strips connecting the bands together by means of flexible micanite as shown in the accompanying illustration. He should first put down his tie strips around the armature, being careful that insulation is placed beneath each tie strip to prevent it from touching the core. Over these tie strips is placed the insulation that goes underneath the bands. The outer bands, *A* and *C* in the accompanying illustration, are then wound on. Insulation should now be placed over the top of the bands *A* and *C* and the tie strip can be bent over this insulation and carried over to the center of the armature where the two ends of the strip may be soldered together, as is shown. Insulation may now be placed over the double thickness of the tie strip for the center band *B*, which may then be insulated and wound on. From the illustration it can be seen that the bands *A* and *C*



Method of anchoring armature bands over coils that slope toward the armature shaft.

are both insulated from the tie strip, and the tie strip holds these two bands from slipping off the ends of the armature by reason of being anchored by the band *B*. J. M. WALSH.
Assistant Chief Engineer,
Gurney Elevator Co.,
New York, N. Y.

* * * *

I was very much interested in the question asked by L. T. M., as I have had several experiences along the same lines that he has encountered. Although it is good practice to band the head of the armature, using clips spaced at short distances around the periphery, trouble may sometimes be caused if the same method is used for banding the core. This is especially true if the magnetic field of the machine is very strong because the trouble will be exaggerated owing to the eddy current generated in the band. I recall very distinctly one instance in which the heat generated by the eddy current was so great that after the armature had been repaired and rebanded, the solder holding the banding wire was melted. The generator was rated at 500 kw., 250 volts, 500 r.p.m., and had 25 banding clips spaced at intervals of 10 in. around the periphery of the core.

To overcome this trouble, new bands were wound around the core, but this time the clips were spaced the same distance apart as the poles of the machine. As this was an eight-pole machine, four clips were used on each band and they were spaced 90 deg. apart. By this arrangement the clips on each band are at any instant under poles of like polarity, and the tendency to induce currents in the band is reduced to a minimum. It is also advisable to have the bands as narrow as possible, using more bands in order to obtain mechanical strength. In the case mentioned above, after the new bands had been applied and clips attached to the core bands, the machine operated without any trouble whatsoever.

In the case of direct-current railway motors, it is almost universal practice, in this country at least, to hold the rotor windings in the slots by means of wire bands. The assumption often made that the losses due to these bands are negligible is not necessarily true. They are often of appreciable magnitude, sometimes sufficiently large to be detrimental to the cooling of the machine. By tests it has been found that the band losses vary according to the 1.7 power of the frequency and from the 1.35 to 1.8 power of the induction, depending upon the width and type of band. These losses were found to be chiefly due to the change in the radial component of the flux as the band passes by the pole tip. For the average band, about 15 per cent of the losses (hysteresis and eddy current) are due to the tangential flux in the band. In large railway motors, losses may under certain conditions amount to 2 or 3 kw. HARRY J. ACHEE.
Chief Electrician,
City of Woodward,
Woodward, Okla.

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In reply to the question by L. T. M. regarding the tying of armature bands with copper strips, I would say that this is always unsuccessful due to the cutting of magnetic lines of force by the strips from one band to another and consequent building up of current in the bands and the connecting strips.

The best way to place these bands is to use increased tension when putting on the band wire. Then it will be unnecessary to link the bands together. Some winders place too much insulation under the bands and when the armature heats up this insulation shrinks and the band becomes loose. Use as little insulation as possible and pull the band wire as tightly as possible. L. T. M. might try linking the bands with strips of bright tin which can be easily soldered and are known to give better results than copper strips. LEE F. DANN.
Chief Electrician,
Donnacona Paper Co., Ltd.,
Donnacona, Que., Can.

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Method of Marking Rubber Gloves. — I would appreciate receiving any information concerning satisfactory methods of marking linemen's rubber gloves which are periodically subjected to electrical tests, as I wish to mark on the gloves the date of the last test. These gloves are used constantly for both inside and outside construction work. Any help that readers can give me will be greatly appreciated.
Lowell, Mass. J. H. J.

In reply to the question by J. H. J., our system of glove testing for a public utility company is to have the gloves tagged with a man's name and consider the gloves as belonging to "John Smith." The record is kept accordingly and John Smith is held responsible for his own gloves.

Each man has two pairs of gloves which are tested at regular intervals for each district. The only requirement necessary in using this method is that the tester should be careful to prevent the tags from being mixed.

Chief Electrician, E. J. MORRISSEY.
Western United Gas & Electric Co.
Aurora, Ill.

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Answering J. H. J., I would say that in marking rubber gloves that are subjected to periodic tests, one is confronted with more or less of a problem. About the easiest way to mark each glove is to turn back the cuff and enter the date of test on the inside of the glove in ink, but this record is likely to be destroyed if the gloves are in constant use. A better method is to assign each man a pair of gloves, to be kept in a light-weight canvas bag. This

bag can be numbered by painting the desired numeral on it. A record is then made of the bag numbers and at stated intervals the gloves are all tested, and the condition of gloves, bag, and leather protectors for the gloves entered on a chart for that purpose, and filed for permanent record. PHIL D. COMER.
San Bernardino, Cal.

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How Much Insulation Should be Put on Cable Splices?—Can some reader tell me how many layers of varnished cambric tape should be used for insulating the splices of lead-sheath power cables of the following voltages: 110, 220, 440, 550, 4,000 and 20,000 volts. Do you think some other kind of tape preferable for this work? I shall be grateful for any information that readers can give me regarding the amount of insulation that should be used when splicing cables of the above voltages, and also for any other information or suggestions as to the best method of handling it.
Toledo, Ohio. S. J. M.

In reply to S. J. M.'s question regarding insulation for power cables, I would suggest using one layer of splicing compound (unvulcanized rubber tape) covered with half-lapped friction tape. The rubber tape should be pulled on tightly enough to stretch it to about half its regular width. This insulation is for use on 110-volt cables. One layer of varnished cambric can be substituted for the rubber, if desired. The rubber will stand about 300 volts per mil of thickness. The varnished cambric tape will stand about 1,000 volts per mil of thickness. The tensile strength of either of these tapes is not great and both should be protected by friction tape or some other protective tape. The average roll of varnished cambric tape is from 0.010 in. to 0.015 in. thick by ¾ in. wide. Other widths and thicknesses can be obtained.

All cables below 600 volts are insulated practically alike, using two or three layers of varnished cambric tape half-lapped and covered with cotton or friction tape. The cotton should be painted or have hot paraffine poured over it because this tape when untreated has a dielectric strength of only 250 volts per mil, but when treated the breakdown voltage is 1,000 volts per mil. On 4,000-volt cables use from three to five layers of half-lapped varnished cambric tape, covered with one layer of treated cotton tape.

The 20,000-volt cable is in the extra-high potential class and should have about six or eight layers of varnished cambric tape and one or two layers of treated cotton tape. Over all conductors one or two layers should be wrapped before the lead sleeve is slipped in place. If the joints are not wiped, several layers of P. & B. tape should be applied over the whole and each layer heated with a torch before another is applied. This class of joint should be painted with P. & B. waterproof paint also. This makes a watertight joint and will remain so if painted at intervals. GRADY H. EMERSON.
Birmingham, Ala.

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General Electric Bulletin No. 87000E recommends for voltages not exceeding 25,000 volts, the use of General Electric splicing rubber to a diameter equal to that over the insulation on each conductor. This is then followed by tape to give a total thickness equal to 1½ times the thickness of insulation on a single conductor. The length of the taping should be 25 times the thickness of the insulation measured from the center of the splice outward or a total of 50 times the thickness for the entire length of splice, tapering the thickness in proportion to the distance from the center. This is followed by taping the individual conductors with a band of varnished cambric in order to separate them. The thickness of this band should equal the thickness of the insulation on the single conductors of the cable. The three conductors are then taped together with two belts of varnished cambric 1½ in. wide and 1½ times as thick as the cable belt, following this with linen twine to prevent unwrapping.

In straight runs of cable I have used a layer of rubber tape followed by varnished cambric, half lapping each layer and painting each layer with a coat of air-drying varnish. This makes a very stiff joint, but it can be made extra tight. The whole secret is in tight taping and uniform lap.
Chief Electrician, E. J. MORRISSEY.
Western United Gas & Electric Co.,
Aurora, Ill.

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Determining Number of Poles in Stator by Use of Compass.—(1) Can some reader give me a simple method of determining the number of poles in two- and three-phase stators when the nameplate is missing? That is, can I pass direct current from dry cells or other source through the winding and use a compass to locate the poles? Or will it be necessary to trace out the winding? How should I go about tracing out a winding to find the number of poles? (2) Why does the terminal on the positive pole of a storage battery corrode, while the negative terminal does not? I shall appreciate your help.
Worcester, Mass. R. S. T.

In reply to R. S. T., I would say that the best way to test a.c. motors for polarity is as follows:

In a two-phase machine, connect one phase to a source of direct current, preferably a lamp bank in series with a 110-volt, d.c. line, and test with a compass for the number of poles. Reversal of the compass needle will indicate when the compass passes from one pole to the next. The number of poles in both windings is the same. The lamp bank also should not permit more than 50 per cent of load current to flow through the winding and usually a much smaller current is sufficient.

In a three-phase, star-connected machine, one of the test leads may be connected to any one of the motor terminals and the other one should be connected to the star point.

In a delta-connected machine, the phases should be separated at one of the terminals, and the test leads should be connected across any phase.

One way to determine the number of poles without the compass test is to count the number of coil groups on the stator and divide that number by the number of phases.

The third method is to use the formula, $P = (f \times 120) \div$ r.p.m., where P = number of poles and f = frequency. As an example let us consider a 60-cycle machine having a speed of 1,800 r.p.m. This machine will have $(60 \times 120) \div 1{,}800 = 4$ poles.
Brooklyn, N. Y. MICHAEL REUTER.

In reply to R. S. T.'s question, I would say that if the motor is in running condition he can find the r.p.m with a speedomotor and by the accompanying table he can tell the number of poles the motor has.

Speeds and No. of Poles of Induction Motors

No. of Poles	60 Cycle Synchronous R.P.M.	25 Cycle Synchronous R.P.M.
2	3,600	1,500
4	1,800	750
6	1,200	500
8	900	375
10	720	300
12	600	250
14	514.2	215
16	450	166.6
18	400	187.5
24	300	125
36	200	83.3

A check may be made also with a compass. Pass a direct current of approximately 5 per cent of the full-load current rating through one phase of the winding; then slowly move a compass around the inner periphery of the stator. On the stator mark the polarities as indicated by the compass. The number of times the compass reverses indicates the number of poles.
HARRY J. ACHEE.
Chief City Electrician,
Woodward, Okla.

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In answer to the question by R. S. T., I would advise that a simple and convenient method of determining the number of poles in a winding is by the use of a compass and battery or other source of direct current, taking care to limit the current flow safely within the carrying capacity of the winding. First, remove the rotor, if this has not already been done. If the winding is three phase and star-connected, connect one lead of the d.c. supply to one motor lead and the other d.c. lead can be connected to the star point, which is the junction of the phase-winding ends.

Then by placing the compass inside the stator and moving it from a given starting point, following around the stator closely to the laminations back of the starting point, it will be observed that the needle has swung through a number of half-turns. Count the number of times the needle has reversed its position; this number will be the number of poles the motor has and will be the number which was stamped on the motor nameplate.

If the motor is three phase, delta-connected, the procedure will be the same as with the star winding except that the delta must be opened and the d.c. supply connected to only one phase. Then use the compass as before.

For a two-phase, four-wire motor connect the d.c. supply to the two motor leads of one phase. For a two-phase, three-wire motor, connect the d.c. supply across the ends of one of the phase windings and count the number of poles as indicated by the compass.
Muncie, Ind. GEORGE CROPPER.

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Replying to R. S. T.'s inquiry, the number of poles may be easily found in two- or three-phase machines by checking the speed of the motor and making a few simple calculations. If a 60-cycle

motor runs 3,600 r.p.m., the winding must be two pole; if 1,800 r.p.m. on 60 cycles, it is four pole; 1,200 r.p.m. for six pole; 900 r.p.m., eight pole; 720 r.p.m. for ten poles, and so on. To obtain the number of poles, simply divide the number of alternations per minute by the r.p.m. The number of alternations per min. for 60 cycles $=7{,}200$, for 25 cycles it is 3,000. Then for 60 cycles the equation will be $(60\times 60\times 2)\div$r.p.m. and for 25 cycles the equation will be $(25\times 60\times 2)\div$r.p.m.

In case the motor is burned out and the nameplate is missing it will be necessary to check the winding. First, count the number of slots or coils and if the motor is three phase, divide the number of coils by three. This gives the total number of coils per phase. Next count the coils in series per pole-phase group and divide this number into the number of coils per phase. This result is the number of poles. The equation is (number of slots or coils $\div$ number of phases) $\div$ number of coils in series per phase group. The following is an example of a three-phase stator having 96 slots and 96 coils: $96 \div 3 = 32$ = number of coils per phase. Then, as there are four coils in series to form a pole-phase group and since $32 \div 4 = 8$ it follows that the stator has eight poles.

The number of poles can also be found by connecting two or three dry cells across one phase of the winding and checking around the inside of the bore of the stator with a compass. Each reversal of the needle indicates a pole and equal numbers of both north and south poles will be found.

Answering R. S. T.'s second question, there are several explanations in regard to the corrosion of the positive terminal of a storage battery. The most likely one is the action of electrolysis. This builds up a greenish-looking substance common to all batteries. The cause is probably the action between the terminals as they are not absolutely sealed from the air and moisture creeps in, causing the deposit to form on the terminal. This can largely be avoided by a generous application of vaseline on the terminal before making the connection.

Chief Electrician, Donnacona Paper Co., Donnacona, Quebec, Can. LEE F. DANN.

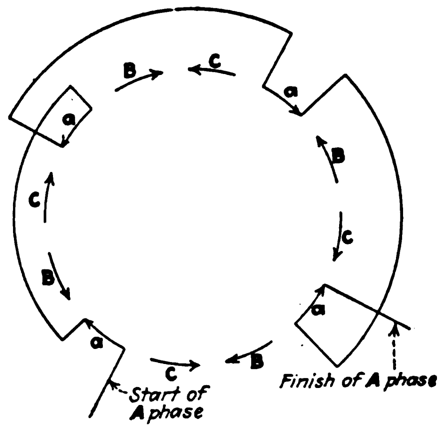
* * * *

The number of poles in a stator can be determined by connecting a battery to the terminals and using a compass to determine the number of poles—as a matter of fact, this is a common test which is frequently employed.

If the machine is star-connected, the battery is applied to the start and finish of a phase, but if it is delta-connected the delta is opened and the battery connected to the two ends opened. A piece of chalk is used to mark the compass deflection on the core as the compass is moved over each pole. The number of times the compass reverses per phase indicates the number of poles.

Another method is to determine the number of coils in a group by counting the series connections. If there are no series connections, then there is but one coil per group; but if two series connections are used, then there are three coils to the group, etc. This does not take into consideration odd groupings, in which groups may have different numbers of coils in them, each circuit or the complete circuit being evenly balanced by proper distribution of coils.

As an example, let us take a machine having 72 slots and, as there are two coil sides to a slot it stands to reason



Method of finding number of poles in a stator winding.

A compass is used to determine the polarity of each pole-phase group, the reversals of the compass indicating when it passes from one group to the next. The number of pole-phase groups divided by the number of phases equals the number of poles.

that there are 72 coils. We find two series connections which make three coils per group and since it is a three-phase machine then it follows that (72 coils $\div$ 3 coils per group) $\div$ 3 phases $= (72 \div 3) \div 3 = 8$, or the machine has eight poles.

In the illustration I have shown a three-phase, four-pole stator with two coils per pole-phase group or a total of 24 coils. The arrow on each pole-phase group indicates the polarity as obtained by a compass. Note that adjacent arrows oppose each other. The number of arrows per phase indicates the number of poles. Only the A phase is shown; B and C are connected likewise and are single-circuit. If this were a two-phase job the arrows would be somewhat different in that they would be in groups of two.

The winding illustrated will have one series connection and is generally referred to as a 1-and-4 connection, or a top-to-top, referring to the fact that the coil side in the top of the slot is connected to the coil in the top of the slot on the next group.

I would suggest the R. S. T. get in touch with the McGraw-Hill Book Co. for books on armature winding. He will find it entertaining and of great benefit in understanding what is going on inside his stators.

The corrosion referred to in the second question is caused by the natural sulphation of the positive terminal, caused by discharging too far or allowing the battery to stand for a long period without charging; wrong specific gravity of electrolyte will also tend to cause this corrosion and it can be cured by correcting the above and by the application of vaseline to prevent sulphation. A method of preventing this formation is overcharging at periodic intervals, but this should be done in a careful manner.

Chief Electrician, Western United Gas & Electric Co., Aurora, Ill. E. J. MORRISSEY.

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In answer to R. S. T.'s query, I would say that if a d.c. power supply is handy, it is quite an easy matter to find out how many poles a stator has, by testing with a compass.

On a star-connected motor, stick a scriber, or any other piece of metal that has a sharp point, into the star connection; tie one line of the d.c. to it, and the other end to one line lead. Now pass the compass around the stator on the inside, and mark the reversals of the compass N and S or + and — on the stator at the point at which the reversals take place.

If you want to check a stator for polarity, you will have to repeat this operation on the remaining two legs, leaving the same d.c. line on the star connection until the test is completed. Always withdraw the compass from the stator before you break the d.c. circuit or you may reverse the polarity of the needle of the compass and upon testing the succeeding phase, misleading results will be obtained. When the test is completed, the polarity marks will alternate. Let us assume that on a certain stator we have made a total of 18 marks, three + marks and three — marks for each of the phases. This proves there are 18 pole-phase groups in the whole stator.

As we were testing a three-phase stator, we must divide the total number of groups by the number of phases therein. Therefore, the stator has $18 \div 3 = 6$, or six poles. Such a stator will have a synchronous speed of 1,200 r.p.m. on 60-cycle power.

The formula to figure this out is as follows: $(120 \times 60) \div 6 = 1{,}200$ r.p.m.

If it were a 50-cycle machine it would run at $(100 \times 60) \div 6 = 1{,}000$ r.p.m.

A 25-cycle machine would run, $(50 \times 60) \div 6 = 500$ r.p.m.

I believe it is much quicker, however, to count the groups, either by the number of leads, or the connections coming out of the winding. There are two leads to a group, one top lead and one bottom lead. Count either all tops or all bottoms, but not the two together. Divide the number of leads counted by 3 for a three-phase stator or by 2 for a two-phase stator, to obtain the number of poles.

This can be done by just removing the end shield on the lead side, while with a compass you would have to slip out the rotor. Also with a delta connection, a compass test might be misleading, unless you open one side of the delta.

To find whether a stator is star- or delta-connected, proceed as follows: If the leads that connect the stator winding with the line connect to only one group, it must be a single-circuit star. If a line lead connects with two groups, the winding is either a two-circuit star or a single-circuit delta. If the two groups come out of the same phase it must be a two-circuit star. To check this, call one group A and count A, B, C, A, B, C, and so on,

until you get to the other group that connects with that line. If this is an A group then you know it is a two-circuit star winding; otherwise, it must be a single-circuit delta winding.

A delta-connected winding will always have twice as many group connections to the line as it has circuits; that is a two-circuit delta will have four group connections to the lines, while a two-circuit star has only two and so on. NICHOLAS J. WEISS.
West New York, N. J.

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Answering the question by R. S. T. I would say that this can be done by applying direct current to the winding. The direct current voltage should be sufficient to cause about 30 per cent of the full-load current to flow.

In checking a three-phase, star-connected winding for the number of poles, the test is made as shown in Fig. 1. The positive lead of the direct-current supply is connected to the *A* lead of the winding and the negative to the star connection. The compass is now moved slowly around the bore of the stator and its deflections noted, marking the bore with chalk, using arrows to indicate the polarity. After completing the test on one phase, the positive lead is shifted to the *B* lead and then to the *C* lead, leaving the negative wire always connected to the star connection. After checking all three phases there should be a circle of arrows pointing in alternate directions as indicated in the diagram.

On a delta-connected winding the test can be made with one set-up as shown in Fig. 2. Here the delta connection is opened at any one of the leads (in Fig. 2, it is opened at the junction of *A* and *B* phases) and direct current applied so that current flows through all three phases in series. If the compass is now passed around the bore of the stator it will indicate alternate polarities just the same as in the test on the star-connected winding.

On a two-phase winding, direct current is applied to the ends of each phase separately, Fig. 3, as *A1* and *A2* or *B1* and *B2*, in which case the correct polarities would be as indicated in the diagram; that is, the pole groups alternate in pairs. Figs. 1 and 2 are both six-pole windings giving a speed of 1,200 r.p.m. at 60 cycles, while Fig. 3 is an eight-pole winding for 900 r.p.m. at the same frequency. P. JUSTUS.
Chief Electrician,
Chandler Motor Car Co.,
Cleveland, Ohio.

When the nameplate of an a.c. motor is missing and all connections are in place, even though the motor is burned out and has to be rewound, the number of poles in the winding may be determined as follows: On two-phase motors there are twice as many coil groups as there are poles; likewise on a three-phase motor there are three times as many coil groups as poles. Therefore, by dividing the number of coil groups by 3 the number of poles may be ascertained on a three-phase motor, and on a two-phase machine there would be one-half as many poles as coil groups.

The coil groups can easily be recognized by the stubs or series connections from each individual coil to the others in that particular coil group. A coil group is seldom less than two coils, in which case there would be one stub; a coil group of three coils would have two stubs, and the remaining two ends would tie to the next coil group in that phase or to the line, in some parallel connections. The number of stubs will be one less than the number of coils forming that particular group.

In counting the groups in a stator of which the nameplate is gone, it is a good idea to check up the number of coils in several groups to be sure that the number is the same in each group. If they are found to be unequal, it is a bastard grouping and the poles will not divide into the number of coils by an even number, a six-pole machine with 48 coils being an example. Here 18 groups are necessary, but 18 goes into 48, 2⅔ times and this would necessitate an unequal grouping. There would be, accordingly, 12 groups of 3 each and 6 groups of 2 each. These would, of course, have to be arranged so that there would be an equal number of coils in each phase, and also so that they would be equally spaced around the stator.

Occasionally, the poles of a storage battery corrode, which is caused by the action of sulphuric acid on some metal other than lead, especially copper. This is probably due to the battery post being loose. R. S. T. will find that the negative will also corrode, but not so much as the positive. Just why the positive corrodes more than the negative I have been unable to find. Commercial vaseline applied to these terminals will prevent this and washing the top of the battery in a solution of common soda dissolved in water will be of aid. A weak solution of commercial ammonia is also good.
Birmingham, Ala. GRADY H. EMERSON.

Direct current is passed through the windings and the number of poles found with the aid of a compass.

Fig. 1 shows how the direct-current should be applied to a three-phase, star connected winding while Fig. 2 shows how it is applied to a delta-connected winding. Fig. 3 shows the method of connecting for a two-phase winding.

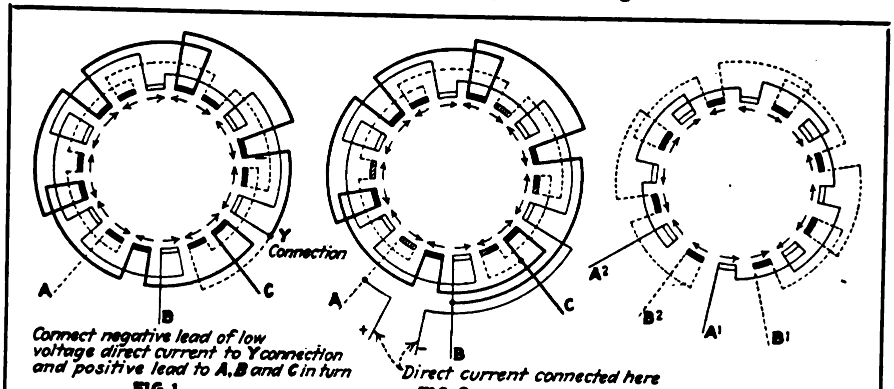

FIG.1 FIG.2 FIG.3

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Drying Out Direct-Current Motors.—One of our largest steel works was recently flooded, due to the breaking of a dam. About 500 direct-current, shunt-wound, 250-volt motors, ranging in size from 10 to 250 hp. have been under water for 10 days. Our problem is to dry out these motors in the shortest time. The greatest difficulty encountered is in drying out the shunt-field coils. Drying out in an oven is rather slow, due to the large number of motors that must be taken care of. I would greatly appreciate learning from readers what methods they would suggest for drying out these motors, particularly the field coils.
Bressoux, Liege, Belgium. P. V. H.

In reply to P. V. H.'s question referring to the drying out of d.c. motors, the writer had a similar experience after a mine explosion in the West where the 500-volt motors used had been under water for several weeks. These motors ranged in size from 5 to 200 hp.

We proceeded at first by stripping the outside insulation off the coils and washing them with benzine. The coils were wiped dry and put in an electric oven used for baking armatures. However, this process was too slow, since the coils dried out on the outside surface only.

It was urgent that we have these motors in operation at the earliest possible time; so we arranged to connect the shunt coils inside the oven in series with a resistor, applying about 75 per cent of normal field voltage, while the oven temperature was regulated at 180 deg. F. for 6 to 12 hr., depending on the size of the coils.

After this treatment the field voltage was raised to normal, the oven temperature was gradually raised to 220 deg. F. and the coils were baked for about 2 hr. The coils were then tested, dipped in a baking varnish, allowed to drip, and baked again for 10 hr. at a temperature of 190 deg. The series and interpole coils were treated as above, except a heavier resistor was used for controlling the increased current required to raise the temperature of the heavier copper. We experienced difficulty in removing the sludge and mud from the armature and interpole coils, but found that by first drying (not baking) the windings and applying a benzine wash, the mud was easily removed. WILLIAM J. MILDON.
Supt. Power & Equipment,
Madeira-Hill Coal Mining Co.,
Philipsburg, Pa.

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Answering P. V. H.'s question, if a generator or other source of power is not available I would suggest that he dry out one of the motors in any convenient manner and use it as a generator. After removing the armatures of the other motors the field windings can be dried out by connecting a number of them in series and passing cur-

rent from this generator through them. This scheme will enable him to save time, if the motors can be grouped conveniently. Care must be taken, however, to limit the current to a safe value so that the windings will not be overheated. Covers should be used for each machine, to keep the heat in. Also, grids or other heating devices may be placed in the base of each unit to furnish additional heat.

For drying out the armatures, I suggest that these be covered with an asbestos pad. Resistance wire of suitable length and size for the voltage employed should be wound over the asbestos covering. When current is passed through the resistance wire it will heat up enough to dry the armatures out very satisfactorily. The asbestos covering is needed as an insulator, as well as to give protection from local overheating.

Vigilance must be exercised during the drying-out process to prevent damage. A temperature of 175 to 185 F. can be safely used and maintained constant by the use of a rheostast or by regulating the generator voltage.

Chief Electrician, E. J. MORRISSEY.
Western United Gas & Electric Co.,
Aurora, Ill.

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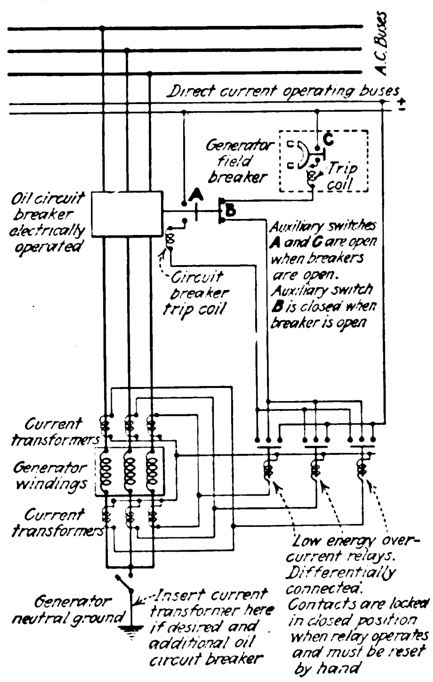
Overload Protection for Generators.—(1) We have installed in our power plant, two 2,000-kva. generators and two 4,000-kva. generators all of which are rated at 2,300 volts, three phase, 60 cycles, 3,600 r.p.m., and are driven by steam turbines. What protection should we have on these generators? Should reverse power relays, or overload relays, or both be used? Are these relays necessary and also what other protection is required on these machines? The four machines are arranged to be paralleled together and quite often all of them are running simultaneously. (2) We have installed one 50-kw., 125-volt, motor-driven generator which operates in parallel with two 100-kw. steam-driven exciters for supplying field excitation for synchronous motors. Should we have circuit-breaker protection on these machines and if so, should a three-pole circuit breaker be used? I shall appreciate any information that readers can give me regarding these questions.
Detroit, Mich. R. J. B.

The following are my answers to R.J.B.'s questions regarding the overload protection required for generators.

(1) The accepted practice, when a number of generators are operated in parallel, is not to install any protection against direct overloads on the generating equipment. This practice is due to the possibility of one of the generators being tripped through faulty relay setting or operation, thus throwing more load on the other generators. This condition is particularly liable to occur when the load is variable and the prime movers driving the generators have governing characteristics which are markedly different.

Experience indicates that protection should be installed only for faults in the generators themselves. This protection should operate as quickly as possible and immediately disconnect a generator when the trouble occurs. For this purpose the so-called differential protection is most used. To apply this, it is necessary, however, to have the ends of each phase winding brought out of the generator winding so as to permit the insertion of current transformers. While this is possible in a new generator, those of the older type usually have only three line terminals and the bringing out of the other three may not be a simple or an easy matter. In these cases a reverse power relay could be installed, but the protection would not be as good as with the differential method.

The accompanying diagram shows the connections for the differential protection of a three-phase generator. The connections are shown for the condition when the main oil circuit breaker is open. This form of protection consists of balancing the current leaving the generator at one end of the winding against the current flowing through the same section but at the other end of the winding. This scheme of protection is usually accomplished by connecting a current transformer at each end of each phase winding, connecting their secondaries in series, and then connecting a current relay across these secondaries, as shown in the diagram. As long as the secondary currents are equal, no current will flow through the relay windings. Any leakage of current, however, to other phases or to ground will upset this balance, and send current through the relay. The relay in turn operates to trip the circuit breaker and disconnect the faulty equipment.



Connection scheme for protection of generators.

This scheme provides what is known as differential protection and puts the generator out of circuit in case of faults developing in the winding. It is deemed inadvisable to protect the generator against straight overloads due to too much load.

The scheme as shown has limitations in that it will not always protect against short-circuited turns in the generator winding. Also, it will not always protect against a low-resistance ground on account of the very small unbalance and also because the very low setting of the relay required would be too sensitive for practical operation. A ground relay can be used if the generator is not connected directly to the bus, but with all machines stepping up separately through transformers there is no trouble. In general the scheme shown is fairly satisfactory without special equipment.

It should be understood that where machines have grounded neutrals and all connect directly to the bus, only one neutral can be closed at one time. Should the generators be operated with a grounded neutral, the differential protective scheme will allow the installation of an additional relay to protect a generator from a fault to ground by inserting a current transformer in the ground connection, as shown in the diagram.

The relay used in connection with differential protection is the same as the straight overload type of relay except that it operates at a much lower current. One manufacturer makes a relay for this purpose that operates at a range from 0.5 to 2.5 amp.

(2) For exciters operated in parallel, experience indicates that a reverse-current relay is sufficient protection. Regarding the question of circuit breakers, nothing is said of the type of machine in service, but under any condition for a straight shunt or compound-wound machine a two-pole breaker on a two-wire excitation system is satisfactory.

C. OTTO VON DANNENBERG.
Designing Engineer,
General Engineering & Management Corp.,
New York, N. Y.

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In answer to the questions asked by R. J. B., I have the following to say:

(1) The general practice, and the one which is more reliable for a power plant installation, is to have the generators installed without overload protection. This practice should be followed when using only one generator, or when there is more than one, for it gives an assurance of continuous operation without the danger of shutdown. Alternating-current generators of the size and capacity which R. J. B. has, are usually well built and solid enough to withstand severe strains and stresses. The winding, as a rule, is lashed to prevent the twisting and raising action caused by overloads. The generators will stand without injury several times full-load current if it is of short duration.

In case of a short-circuit, turbine-driven, alternating-current generators will deliver about 15 times full-load current for a few seconds after which the current will drop to about one and a half to two times full-load current. This is because of two factors: The reactance of the generator winding, and the degree of field excitation that the exciter will furnish under the circumstances at the time. These things make generators of this class able to take care of themselves in case of extreme overloads, or at least, until an attendant can correct the trouble. If over-load protection were used and trouble should occur on the system, such as a short-circuit, ground, failure or stalling of a large motor, or a heavy line surge, enough current might be taken to cause the overload relay to trip, thereby shutting down the entire plant, while if the generator did not have overload protection, it would take care of the overload until the overload relays on the

feeder switch protecting the circuit on which the trouble occurred, could operate and open the switch, thereby cutting off only the one circuit and thus preventing a station shutdown. With proper operation and attention, it will not be necessary to have either the overload relays or the reverse power relays for generator protection. The power plant operation will be more satisfactory without them, as far as power troubles are concerned.

(2) If the motor-driven, direct-current generators and the turbine-driven exciters are used to excite the fields of the alternators, there should be no circuit breaker protection on them for if the circuit breakers should open from any cause whatsoever, the alternator field would be killed which would result in a complete interruption to the electrical power output of the station. If the exciters are being used to excite the field of the synchronous motors only, circuit breakers could be used if desired, but even for motor field excitation it would be better not to use a circuit breaker, for if by chance the breakers should open while the motors were loaded, the motors would take such a large amount of current that the windings would be ruined within a very short time unless proper overload protection were provided for the motors.

Muncie, Ind. GEORGE CROPPER.

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Trouble with Solder.—We are having considerable trouble in making soldered joints hold on rectangular wire in coils that are subjected to rather high temperature, such as might be the case in series field coils and brake series coils. We have tried an 80 lead—20 tin solder, but it melts due to the excessive heat. Can our readers suggest any methods that will enable us to join these wires together in a manner that will stand rather high temperature? I shall be very much indebted to any reader who can give me some help in this matter.

Norton, Va. W. H.

Replying to W. H.'s question in the March issue, I would say from past experience that the trouble is due to high resistance in the joints, rather than high operating temperatures. If W. H. will use a 95 per cent pure tin solder, I feel quite sure that his troubles will disappear.

While this type of solder has a much lower melting point than the kind he is using, it also has a much lower resistance, thus causing less local heating at the joint. I have had exactly the same trouble with field and armature connections and in both cases it was eliminated by the use of 95 per cent tin solder. R. R. SCHELLENGER.

Electrical Engineer,
Elk Horn Coal Corp.,
Wayland, Ky.

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In answer to W. H.'s question relative to trouble with solder on series field and brake coil connectors, the usual custom is to allow the ends of the wire to extend far enough beyond the coil being wound to double the wire and use a suitable connector or clamp which will eliminate the soldering process. If this is inconvenient, the splice or connection can be brazed with a spelter composed of four parts zinc to one part copper. This alloy melts at a temperature of 1,275 deg. F. The melting temperature can be raised by addition of copper.

To braze, it is important that the spelter should melt at a lower temperature than the material to be brazed and that the ends of the wires should be thoroughly cleaned. Apply a small amount of a good brazing flux and keep the neutral flame of a small acetylene torch moving over the part to be brazed, to prevent it from fusing. When space is limited, it may be advisable to use pieces of sheet asbestos to prevent overheating of the insulation.

WILLIAM J. MILDON.

Supt. Power & Equipment,
Madeira-Hill Coal Mining Co.,
Philipsburg, Pa.

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Changing 25-Cycle Brake Coil to 60-Cycle Service.—I am having a little trouble in changing over a brake coil from 25-cycle to 60-cycle service. This coil is used on the brake on the hoist motion of a 10-ton traveling crane. The coil was originally wound with about 1,400 turns of No. 21 magnet wire for 25-cycle service. I have rewound the coil using 800 turns of No. 15 wire, but the coil only lasted a few days before burning out, and it does not seem to have the lifting power of the old coil when used on the 25-cycle service. This coil was formerly connected across a 440-volt, 25-cycle power supply and will be used on the same voltage for the 60-cycle service. The diameter of the smallest turn is about 2 in. and the largest turn about 4 in. The coil is in reality a solenoid with a plunger working through the center of it. Can some reader tell me how many turns to use on this coil and what size of wire should be used in order that I may use it on the 60-cycle power supply?

Green Bay, Wis. H. B.

In reply to H. B.'s question, the number of turns in the coil is, for practical purposes, inversely proportional to the frequency, thus: $N_1 : N_2 :: F_2 : F_1$, where N_1 and F_1 represent the original number of turns and frequency, respectively, and N_2 and F_2, the new number of turns and frequency. Then $(1{,}400 \times 25) \div 60 = 583$, say 600 turns.

The corresponding larger size of wire to use is No. 17. Since the winding volume is not given, I checked this, based on s.c.c. wire and find that No. 17 wire will not quite fill the winding space. Therefore, each layer of wire should be well insulated from the succeeding layer by dry insulating paper, to make the diameter of the coil as large as conditions will permit to reduce the heating.

The coil apparently is used on a shunt brake, intermittent duty and should be dipped or impregnated in insulating varnish. In many cases it is cheaper to obtain the proper coil from the manufacturer of the apparatus as it is oftentimes difficult to wind and treat coils properly with the equipment at hand.

Bobbin-wound coils are dipped in heated insulating varnish and then baked for several hours. Form-wound coils are impregnated by being placed in vats with the insulating compound and subjected to pressures up to and including 100 lb. per sq.in. The coils are then removed and baked for several hours in an 18- to 20-in. vacuum. This treatment removes all of the moisture and keeps the coil from absorbing moisture. Also, the insulation between adjacent turns and layers is very much improved. E. H. LAABS.

Engineering Dept.,
The Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

In reply to H. B., if this brake coil is wound with 585 turns of No. 17 wire, I think no further trouble will be experienced.

Whenever the line frequency is increased 2.4 times, the number of turns has to be decreased accordingly, since increasing the frequency increases the impedance.

As the resistance is very small in comparison to the reactance the turns will have to be reduced to $(25 \div 60) \times 1{,}400 = 583$ turns. No. 21 wire has an area of 810 circ.mils and in order to increase the size 2.4 times, the area would have to equal $810 \times 2.4 = 1{,}944$ circ.mils. No. 18 wire has an area of 1,624 circ.mils and No. 17 has 2,048 circ.mils; therefore, No. 17 would be the better size to use. However, as the same amount of work is expected of the coil, that is, foot-pounds to be lifted, and since it is also operated on the same voltage, the size of wire is not so important as might at first be thought.

The reason why the rewound coil did not stand up under the new frequency was because the number of turns was not decreased sufficiently to reduce the impedance to its original value. This cut down the current flow below its former value. With the consequent reduction in flux, the coil was not able to lift the plunger high enough so that the reactance would cut the current to a safe value.

NICHOLAS J. WEISS.

West New York, N. J.

* * * *

H. B.'s problem is one which can be solved by using the old transformer formula, maximum flux = (volts $\times 10^8$) $\div$ (4.44 $\times$ turns $\times$ frequency). To obtain the same lifting power from the solenoid on a 60-cycle supply as on a 25-cycle supply, the voltage remaining constant, it will be necessary to keep approximately the same value of maximum flux.

It is evident from the formula that the number of turns in the coil must be changed inversely as the frequency, that is, the number of turns are decreased in the same proportion that the frequency is increased. Therefore, the correct number of turns for the new coil must be $(25 \times 1{,}400) \div 60 = 584$.

H. B. will be able to see why the lifting power with 800 turns was not so great on 60 cycles as it was with 1,400 turns on 25 cycles. The maximum flux was only $(25 \times 1{,}400) \div (60 \times 800) = 0.73$ or about 73 per cent of what it was before. The reason for the coil burning out with this winding of No. 15 wire was probably the lack of pulling power to raise the plunger to a point in the coil which would make the reactance great enough to cut down the current to a safe value.

A No. 17 B. & S. gage wire could be wound in the coil space very nicely with 584 turns and should give a coil which will perform as well on 440 volts, 60 cycles, as the old coil did on the 440-volt, 25-cycle power supply.

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Electrical Service

around the works

For this section short articles describing ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing, and emergency or special installations.

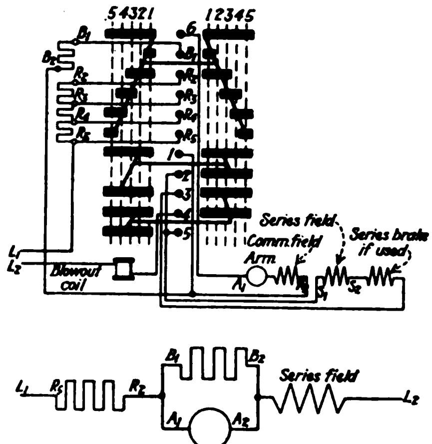
Comparative Advantages of A.C. and D.C. Motors for Larry Car Service

WHEN larry cars are propelled at constant speed, the question of whether to use a.c. or d.c. motors is often very properly determined by the kind of current available. Alternating current can be used but the following disadvantages will be encountered, some of which can be overcome by proper application and installation of the motors and other equipment.

(1) Alternating current requires the installation of an extra trolley wire or rail with extra insulated supports, guards, and so on, as well as additional labor for installing. (2) The induction motor has a maximum torque for starting and under some conditions would fail to move the load, whereas a d.c. series motor, if correctly applied, would either move the load or slip the wheels. (3) The starting current drawn from the line by a d.c. series motor is much less for the amount of torque exerted. (4) The series motor speeds up under light loads and will propel a light car faster than the a.c. motor. (5) With a series motor it is possible to obtain creeping speeds with either high or low torque. As an induction motor is inherently a constant-speed machine, it has a very steep characteristic at partial speeds and becomes very unstable, particularly at low torque values. (6) In case the supply voltage is low, the torque exerted by an induction motor is reduced to direct proportion to the square of the impressed voltage, that is, if the voltage were 90 per cent of full value, the torque would be 81 per cent. Reduction in d.c. voltage has no effect on the torque of a series motor. All of these objections, with the exception of (5) can be overcome if the motors are properly applied.

It is difficult to obtain slow speed with an induction motor, although slow speed can be obtained by the use of a d.c. series motor with properly designed control equipment. If low speed running is required with high torque, fair results can sometimes be obtained with an induction motor by putting an artificial load on the motor by a solenoid brake and inserting resistance in the secondary. This method is not economical of power and also puts considerable extra wear on the brake. Slow speed and low torque are practically impossible to obtain with an induction motor and the advantages of the d.c. series motor become more pronounced.

An illustration of motor requirements may be seen in a foundry which has a larry car for hauling sand to the leaching boxes, where the sand is poured into the sand boxes, then smoothed over by means of a plow, and finally sprinkled, after which the larry car returns to the sand chute. All of these operations are performed by the car. When hauling the sand, moderate torque and high speed are required. In spreading the sand, high torque and low speed are required. For sprinkling, low torque and low speed are required. Fig. 1 shows the characteristics of a slip-ring, variable-speed, induction motor of the type generally used in crane hoist service. The accompanying table gives the operating requirements of the motors based on the various operations of the larry car.



Connections on 1st. controller point

Fig. 3—This shows the controller connections for a series d.c. motor on a larry car.

Comparing the a.c. data in the table with Fig. 1 it will be noted that points *A* and *B* are 96 and 98 per cent speeds respectively. This is according to what one would expect, since the induction motor is essentially a constant-speed machine. In other words the larry car returns empty at only a slight increase in speed. Points *A* and *B* in Fig. 2, which give the characteristics of the d.c. motor, show 140 and 170 per cent speeds respectively. A series motor speeds up under light load and consequently the car will be returned empty for another load of sand at a higher speed.

Referring to operation 3 in the table, it will be noted that the car must proceed under heavy load and at slow speed, because the plow is spreading the sand and the speed should be reduced to approximately 9 per cent. In Fig. 1 it will be seen that 9 per cent speed and 98 per cent torque occur at point *C*. It should also be noted that point *C* occurs on curve No. 4, which is obtained on point No. 4 of the controller shown in Fig. 3. This is a very unstable point as is evidenced by the steepness of the curve. If the torque is increased from 98 per cent to 108 per cent, due to the binding of the car wheels on the track or some other cause, the car will stop. If the torque is reduced 10 per cent due to a slight dip in the track, the speed will be doubled. Referring to the corresponding point *C* in Fig. 2 an increase or decrease in this amount of torque on a d.c. series motor will mean an increase or decrease in the speed of only approximately 1 per cent. This is due to the flatness of the curve which is obtained by a shunted armature connection, as shown in Fig. 3.

In order to propel the car when sprinkling acid, it is required to have a creeping speed of 26 per cent; the torque is then light instead of heavy because the larry car has dumped its load of sand, and the plow for spreading the sand has been raised. For the induction motor, the conditions which caused unstable operation at slow speed and heavy torque have now become aggravated, due to the decrease in

Load and Duty Cycles for A. C. and D. C. Motors in Larry Car Service

Operation	Per Cent Torque A.C. or D.C.	Per Cent of Speed A.C.	Per Cent of Speed D.C.	Points on Curves
1. Propel car at full speed with load of sand	39	96	140	A
2. Propel car at full speed empty	20	98	170	B
3. Propel car when spreading sand	98	9	9	C
4. Propel car when sprinkling acid	20	?	26	D

torque. Point D in Fig. 1 falls on curve No. 1 which is the first point on the controller. It will be seen that a very small increase in torque will stall the motor and a very small reduction in torque will accelerate the motor to practically full speed. In fact, the speed-torque curve of the induction motor becomes very steep at this low range of torque, so that it is rather difficult to tell the exact speed because of the large variation for a slight increase or decrease in torque. In Fig. 2, point D falls on the shunted armature connection curve. As in cases of spreading sand at high torque and low speed, a moderate increase or decrease in torque will not materially effect the speed of the car and for practical purposes may be disregarded.

As suggested previously, fairly passable results can be obtained from the induction motor by putting an artificial load on it and inserting resistance in the secondary. This results in placing the operating point on a flatter curve. For example, enough load can be put on the motor by tightening the brake to get 62 per cent of full-load torque and the resistance in the secondary will be obtained by advancing the controller handle to the third point, or E in Fig. 1. It will be seen that operating conditions here are much more stable than at point D on the same diagram, but do not compare with operating conditions as given for point D of the series motor, in Fig. 2. If a very considerable amount of running is done with the brake "on," it may result in excessive wear and heating of the brake shoes. This method should be recommended only for short and occasional operation; it should never be used for continuous service.

With the series motor, it is possible by adjusting the values of resistances R_1, R_2 and B_1, B_2, to get various slopes for the first curve at the bottom of the diagram in Fig. 2 to suit practically any combination of torque and speed that the conditions require. If the values of R_1, R_2 are increased, they will cause this curve to become flatter and to cross the abscissa at a higher torque value. It will also slightly increase the value at which the curve crosses the ordinate at zero torque. Increasing B_1, B_2 instead of R_1, R_2 will have exactly the reverse effect and will give a steeper curve. In this case, it is assumed that the high-torque, slow-speed point C is somewhat lower in speed than the low-torque, low-speed value D. This lends itself to the slope of the shunted armature curve. If it is necessary to have the high-torque point C at a higher speed value than 26 per cent shown at D, it will be necessary to use a controller which will provide two shunted armature points.

The use of the shunted armature connection has certain limitations in obtaining a creeping speed. If the speed is so low that a very flat, low curve is required, it may mean a shunted current of high value with a resulting large number of resistance boxes. This would not be economical of space or power.

In the great majority of cases found in the various industries, where a creeping speed is necessary, the requirements are such, however, that the shunted armature connection can be successfully used. R. F. EMERSON.

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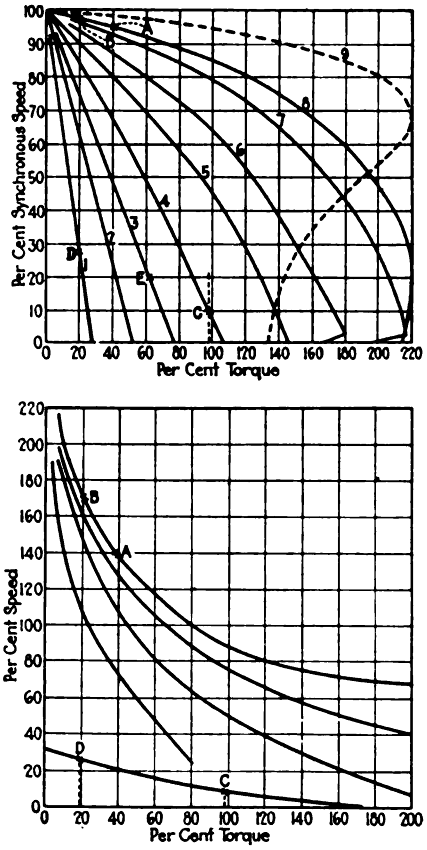

Figs. 1 and 2—Operating requirements for alternating- and direct-current motors in larry car service.

Fig. 1 shows the speed-torque curves for a slip-ring, variable-speed induction motor. The numbers on the curves correspond to the various positions of the controller. Fig. 2, speed-torque curves of d.c. series motor.

How to Determine Power Factor with Slide Rule

NOW that the slide rule is losing most of its mystery, some of the practical uses to which it may be put are interesting to know. It is often desirable to calculate the power factor of a circuit, a load, or a motor, when it is not possible to get simultaneous readings in kilowatts, amperes and volts. Most formulas for finding power factor require the use of trigonometric tables; a slide rule, however, will do just as well and is handier to use.

For three-phase circuits, the power factor may be found by using a slide rule and the formula $(a - b) \div (a + b) \times \sqrt{3}$ = the tangent of the angle of which the cosine is the power factor. In this case a and b are either the readings of two integrating wattmeters or the single-phase readings from a polyphase wattmeter. The expression $(a - b) \div (a + b) \times \sqrt{3}$ may be replaced by reactive kva. ÷ kw. when the readings from a wattmeter and from a reactive kilovolt-ampere meter are available. The expressions just given may be solved with or without the slide rule, as desired, to compute the value of the required tangent.

In using the slide rule, the following procedure is required: Set the slide so that the end of the 45-deg. line or the tangent scale coincides with the end of the D scale. Then place the hairline against a number on the D scale corresponding to the tangent value previously found, and read off the angle on the tangent scale. Since the slide rule has no cosine scale but tangent and sin scales only, the sin scale has to be used. The cosine of an angle is equal to the sin of its complement or its difference subtracted from 90 deg. Therefore, subtract the angle already found from 90 deg. and with the slide in the same position, and the hairline placed against this complementary angle on the sin scale, read the sin value on the A scale. This number is the required power factor.

For tangent values below 0.9, the following method, although a little longer, will be found more accurate on account of the difficulty of obtaining accurate readings near the right-hand end of the sin scale, due to close spacing. For any angle, the sin divided by the tangent is equal to the cosine. Following the same procedure as before find the tangent value and read off the corresponding angle on the tangent scale; then on the A scale read the sin value of this angle (this is not the complementary angle) on the sin scale. Set the slide to divide this sin value by the tangent value already found and the quotient will be the power factor. Although this method may appear rather cumbersome and requires a long explanation, it will be found easy to apply with very little practice and the power factor can be worked out to within ½ per cent in less than a minute.

A few examples will illustrate the procedure. Suppose you are using a polyphase recording wattmeter to check the load on a motor and you want to know the power factor. Take two single-phase readings by disconnecting either the potential or the current coil, as most convenient, first on one phase and then on the other. We will say that the single-phase readings are 414 and 126 respectively. Substituting these values in the formula, $(a - b) \div (a + b) \times \sqrt{3}$ to find the tangent, we will then have $(414 - 126) \div (414 + 126) \times 1.732 = 0.923$, the required tangent. Now set the hairline at 923 on scale D, with the slide placed so that the scale ends coincide; the corresponding angle on the D scale will be 42 deg. 40 min., approximately. Since 0.923, the value of the tangent, is over 0.9 use the first method. Subtract 42 deg. 40 min. from 90 deg.; this gives 47 deg. 20 min. Using the sin scale and the A scale, read the sin value of the angle 47 deg. 20 min., which is found to be 0.735. This value of 0.735 is also the cosine of 42 deg. and 40 min. and is the required power factor.

Again, if the average power factor of a load is required for say a month from the readings of two integrating wattmeters, which are 72,850 kw.-hr. and 43,710 kw.-hr. respectively, substituting in the formula (72,850 —

43,710) ÷ (72,850 + 43,710) × 1.732 = 0.433, the required tangent. Set the hairline against 433 on scale *D*, as before, and read 23 deg. 25 min., approximately, on the tangent scale. As 0.433, the value of the tangent, is less than 0.9 the second method is more accurate. On the *A* scale read the sin of the angle 23 deg. 25 min., which will be about 0.397. Divide 0.397, the value of the sin, by 0.433, the value of the tangent. This will give 0.917, approximately, as the power factor required.

When it is necessary to find the power factor from the readings of the wattmeter and a reactive kilovolt-ampere meter, all that is necessary is to divide the reactive kva. reading by the kw. reading, the quotient giving the tangent of the angle of which the cosine is the power factor. Then proceed as in the examples given, according to whether the tangent value is above or below 0.9.

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Chart for Determining Horsepower of Slope Hoist Motors

IN COMPUTING the horsepower necessary to operate slope hoists, the cycle of operation is hard to determine, but the following approximate method will give horsepower values sufficiently close for all practical purposes.

The total unbalanced weight to be hoisted may be calculated or estimated. Maximum values should be used if the hoist is to be operated continuously, and if it is to be used only for intermittent service, the motors should be able to carry the overloads for a short time. This is usually taken as ½ hr., and if the motor does not overheat in this length of time, it is assumed that it will be sufficiently large to carry all loads that may be imposed upon it. The selection of the values should be made with due consideration for the limitations of the installation; in some cases even the track and rope friction have to be figured.

Per cent grade is found by dividing the difference in elevation by the distance hoisted. Some difficulty may be encountered when the grade is very flat in some places and comparatively steep in other places. In any event, it is necessary to hoist the load and for that reason one should consider the steepest grade.

Hoisting speed in feet per minute would, under most circumstances, be an average value of the load speed. The maximum value used would be dependent upon the curves and the other physical characteristics of the track. The hoisting speed, per cent grade, and total unbalanced weight are directly proportional to the horsepower necessary for the hoist motor, but the efficiency of the mechanism is inversely proportional to the horsepower.

The over-all efficiency of the hoist will be the one factor that may be increased by proper care and attention and will also be governed by the method of speed reduction used. The over-all efficiency will decrease as the hoist becames older and eventually the apparatus will be uneconomical to operate. Since the efficiency decreases with age, the first or assumed value must be liberal, so that the motor will continue to operate the hoist for several years.

In laying out the accompanying chart, the following formula was used: Hp. = $(W \times P \times V) \div (16.5 \times E)$, where hp. is the horsepower of the hoist motor, *W* the total unbalanced weight in tons, *P* the per cent grade, *V* the hoisting speed in feet per minute, and *E* the efficiency of the hoist. The per cent grade and the efficiency are used as decimals on the chart.

This chart is used for determining the horsepower required by motors to operate slope hoists.

Assume that an unbalanced load of 10 tons has to be hoisted up a 10 per cent grade at 1,000 f.p.m., with an efficiency of 60 per cent for the hoist and reduction gears. A straight-edge placed at 10 on the *A* scale and 10 on the *B* scale will intersect the *C* scale at point *J*. Connect point *J* with 1,000 on the *D* scale and it will intersect the *E* scale at point *L*. Place the straight-edge on point *L* and 0.6 on the *F* scale and it will intersect the *G* scale at point *N*, which reads 100 hp., for the required motor rating.

In using the chart, note that the scales are lettered consecutively *A* to *G* in the order of their use. First place a straight-edge on the value of the unbalanced weight to be hoisted and on the value of the per cent grade. The intersection of the straight-edge on the pivot scale *C* is noted. Then place a straight-edge on this point of intersection on the *C* scale and the value of hoisting speed used, on the *D* scale, and note the intersection of the straight-edge on the pivot scale *E*. Do likewise with this point of intersection on *E* and the efficiency value required on scale *F* and note the intersection point on the *G* scale. This point on the *G* scale is the value of horsepower necessary for the conditions given. The problem worked out on the chart will illustrate the procedure.

This chart will be found a time saver, as a ready reference and, after a little practice, extremely simple to use. The range of values are so determined that they will meet the usual requirements.

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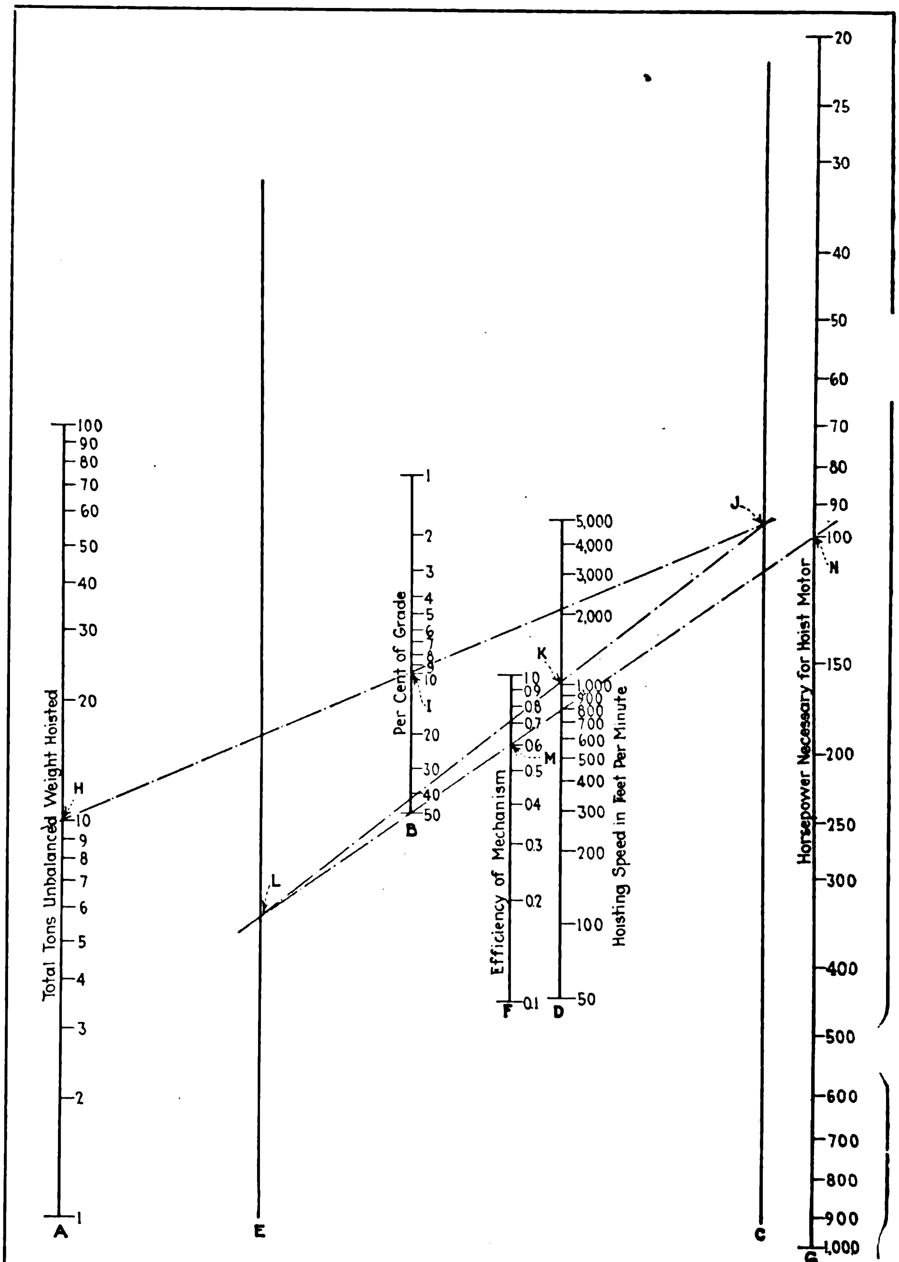


Mechanical maintenance of

Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through the auxiliary transmitting equipment to all driven machines.

Selecting Worm Gear Speed Reducers of Proper Capacity

THE gear speed reducer has become a very important factor in the past few years as a menas of stepping down high-speed commercial motors and other prime movers where they are to function with machinery and equipment operating at lower speeds. This same statement applies equally to the spur, worm, and herringbone gear types of speed reducers, all of which have certain uses for which they are best adapted.

The worm gear speed reducer is suitable for use in installations where the direction of the power drive must be changed at right angles. This article will be confined to a discussion of the worm gear speed reducers with particular attention to how these reducers can be applied in meeting individual speed reduction or power transmission problems. Basic information giving formulas and a knowledge of the applications of speed reducers to practical problems is important to the executive or engineer, when he has in mind the use of speed reducers in new equipment, or for replacements. This article follows closely the lines of a previous article (page 96, February, 1926) which described the methods employed in the selection of spur gear speed reducers of proper capacity.

In dealing with worm gear speed reduction problems practically the same information relative to loads, horsepower and torque, is necessary in making the calculations as is required for the spur gear type. It must be remembered that, theoretically, the same horsepower is delivered by the reducing units as is delivered by the prime mover. The speed, however, decreases through the worm reducer, depending upon the reduction ratio used, and the torque or twisting moment correspondingly increases.

It must be borne in mind, also, that worm drives are inherently less efficient than spur gear reducers, and the power delivered to the driven unit will be considerably less than the power received, because of frictional and other losses in the worm drive. Therefore, this factor must be considered in making calculations. The formulas to be used in making computations for spur gear speed reducers and examples of their application were given in the item which appeared on page 96, in the February, 1926, issue of INDUSTRIAL ENGINEER and will not be repeated here. To make a proper selection of the correct size of worm gear reducer to meet a given set of conditions, it is necessary to have a clear understanding of the relation of the various elements involved. Simple formulas show the relation of horsepower, load, and torque, and how to calculate the capacity of worm gear speed reducers required to meet certain conditions. The symbols used in the formulas are as follows:

P = Load in pounds on drum or pulley.
P_1 = Standing load in pounds on worm gear.
$2\pi R$ = Circumference of worm gear (inches).
N = Revolutions per minute (r.p.m.).
T = Torque or twisting moment in inch-pounds.
W = Work done.
$Hp.$ = Horsepower. (33,000 ft.-lb. per min.)

Torque or twisting moment is that force which tends to produce rotation in a shaft or pulley and is equal to the product of the force acting times the length of the lever arm. This is expressed by a formula, $T = P \times R$ (see Fig. 1).

Work done is equal to the product of the force acting on the object, times the distance through which it moves. When D = distance traveled, then $W = P \times D$.

The distance through which the force acts in one revolution is equal to the circumference of the circle, which is $2\pi R$. Work done in one revolution is expressed, $W = P \times 2\pi R$ in.-lb. Where the drum or pulley makes more than one revolution the total work done will be, $W = P \times 2\pi R \times N$ in.-lb.

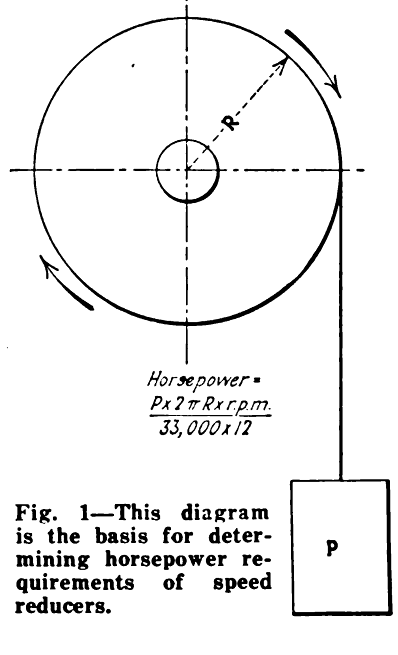


Fig. 1—This diagram is the basis for determining horsepower requirements of speed reducers.

Since 1 hp. is equivalent to 33,000 ft.-lb. per min., the horsepower required to revolve the pulley N times per minute against the weight P will be: $Hp. = (P \times 2\pi R \times N) \div (33{,}000 \times 12)$.

Other useful formulas derived from these equations are as follows:

$Hp. = (T \times N) \div 63{,}025;$
$T = (63{,}025 \times \text{hp.}) \div N;$
$T = P \times R;\quad P = T \div R;$
$R = T \div P;$
$W = 2\pi \times T \times N.$

In dealing with worm drives it is necessary to take into consideration standing and running loads on the gear teeth. By standing load is meant the back pressure on the gear due to the load on the driven unit while at rest. Thus, Fig. 2, by applying the formula for torque it will be found that the torque necessary to move the load on the driven shaft will require a gear with radius R, but the standing load on the gear will make necessary a gear of larger radius, R_1, on such applications as elevator hoist drives, and the like.

To arrive at the proper radius for the worm gear in cases of this kind it is necessary to calculate standing and running loads, as follows: $P_1 = (P \times R) \div R_1$, but $T = P \times R$, then $P_1 = T \div R_1$ and $R_1 = T \div P_1$. Then R_1 will be the radius of the worm gear strong enough to withstand the standing load.

By using one or more of the above formulas it is possible to solve practically any speed reduction problem which may be presented; some of the methods used are indicated in the simple problems which follow. Let it be borne in mind, however, that in actual practice, the efficency of both the reducer and the driven machine must be considered, when selecting reducers of the proper size. Some examples of the practical applications of these formulas on worm gear speed reducer problems may be given as follows:

(1) If we have a drum with a radius of 6 in. and a load of 1,000 lb. to be moved, find the torque necessary to move it.

$T = P \times R = 6 \times 1{,}000 = 6{,}000$ in.-lb. torque.

(2) If the drum is to be driven at 1 r.p.m. how much work will be done during this revolution?

$W = 2\pi \times T \times N = 6.28 \times 6{,}000 \times 1 = 37{,}680$ in.lb.

(3) How much horsepower will be required to drive the above drum at 15 r.p.m.?

Hp. = ($2\pi R \times P \times N$) ÷ (33,000 × 12) = (6.28 × 1,000 × 15) ÷ (33,000 × 12) = 1.42 hp.

(4) If we knew that the torque on the drum shaft was 6,000 in.-lb. and the speed 15 r.p.m., what horsepower would be required to drive it?

Hp. = ($T \times N$) ÷ 63,025 = (6,000 × 15) ÷ 63,025 = 1.42 hp.

(5) If 1.42 hp. is required to drive this drum at 15 r.p.m. what is the torque in inch-pounds on the center of the drum shaft?

T = (63,025 × hp.) ÷ N = (63,025 × 1.42) ÷ 15 = 6,000 in.-lb.

(6) If the torque or twisting moment at standing load on the drum is 6,000 in.-lb. and radius of the drum is 6 in., what is the load on the drum in pounds?

$P = T \div R$ = 6,000 ÷ 6 = 1,000 lb.

(7) If the torque on this drum is 6,000 in.-lb. and the load on the drum is 1,000 lb., what is the radius of the drum?

$R = T \div P$ = 6,000 ÷ 1,000 = 6 in. radius or 12 in. diameter.

(8) If the drum radius is 6 in., the load 1,000 lb. on the drum, and the radius of the worm gear is 8 in., what is the standing load on the worm gear?

$P_1 = (P \times R) \div R_1$ = (1,000 × 6) ÷ 8 = 750 lb.

(9) If the torque on the drum shaft is 6,000 lb. and the standing load on the worm gear is 750 lb., what must be the radius of the worm gear to withstand the load?

$R_1 = T \div P_1$ = 6,000 ÷ 750 = 8 in. radius or 16 in. diameter.

Let us now assume the conditions for a problem and carry the calculation through to the selection of the proper size and type of worm gear reducer to do the work. Assume that we have an elevator whose efficiency is 95 per cent (i.e., the friction loss in bearings, sheaves, and so on equals 5 per cent). The elevator drum or sheave shaft is 18 in. in diameter and is to be driven by a worm gear speed reducer at a speed of 15 r.p.m. The total load to be lifted is 3,548 lb. Speed of the driving motor is 800 r.p.m. The computations are as follows:

Hp. = ($2\pi R \times P \times N$) ÷ (33,000 × 12) = (6.28 × 9 × 3,548 × 15) ÷ (33,000 × 12) = 7.6 hp.

As the efficiency of the elevator is 95 per cent, the actual hp. required will be: 7.6 ÷ 0.95 = 8 hp.

Assume the average efficiency of the worm gear speed reducer as 70 per cent; therefore, the size of motor required will be 8 hp. ÷ 0.70 = 11.43 hp. (Size of motor required which also indicates the load on the reducer.) The reduction ration is 800 to 15 or 53.33 to 1.

Manufacturers generally list reducers according to capacities and reduction ratios and with the above information a selection of the proper machine can be easily made. It is necessary, also, to calculate the actual standing load for this particular problem and compare it with the safe standing load listed by the manufacturer, to make sure that the reducer selected will withstand the load. Standing load is determined as follows:

$P_1 = (P \times R) \div R_1$ = (3,548 × 9) ÷ 13.5 = 2,365 lb.

The capacity of the driving unit must always be great enough to compensate for frictional and other losses in the reducing unit and driven unit and to start the load on the driven unit even though the power required while running is much less.

The efficiency of worm gear speed reducers varies considerably, depending upon the following factors, which are listed in the order of their importance:

(*a*) Helix angle of the worm.
(*b*) Pitch line speed of the worm.
(*c*) Materials used in the worm and worm gear.
(*d*) Nature of lubricant used.

(*a*) The curves in the accompanying chart (Fig. 3), clearly show the relation of helix angle to efficiency. To use the above efficiency curves it is first necessary to determine the lead or helix angle, as the figures used across the bottom of the curve, Fig. 3, represent degrees. To obtain lead or helix angle use the following formula.

A = Helix angle; L = Lead in inches.
$P.D.$ = Pitch dia. of worm.
Tan $A = L \div P.D.$

The accompanying table gives values for the tangent in steps varying from 5 to 45 deg. which will assist in locating on the efficiency curve the result arrived at by solving the above formula for various leads and pitch diameters of the worm.

Values of Tan A for Helix Angles

Tan. A	Deg.	Tan. A	Deg.
0.087	5	0.577	30
0.176	10	0.700	35
0.267	15	0.839	40
0.363	20	1.000	45
0.466	25		

In cases where worm reduction units are operated under heavy loads at comparatively slow speeds the efficiencies will be considerably lower than indicated by the curve. In such cases the efficiency may be increased somewhat by using a heavy grade of lubricant which prevents the oil film from squeezing out and breaking down.

(*b*) The factor of the pitch-line speed of the worm should be considered in selecting worm reducers, and motors to operate them. Pitch-line speed of worm should preferably stay below 1,000 f.p.m.

(*c*) Long experience and numerous tests by reducer manufacturers have indicated that the combination of a steel worm and bronze worm gear give good results and high efficiency for continuous service. For intermittent service, the steel worm and semi-steel worm gear have been found very satisfactory.

(*d*) The influence of the lubricant used on the efficiency is a minor factor, but the highest efficiencies will be maintained by following the recommendations of the manufacturer for lubrication of a given unit.

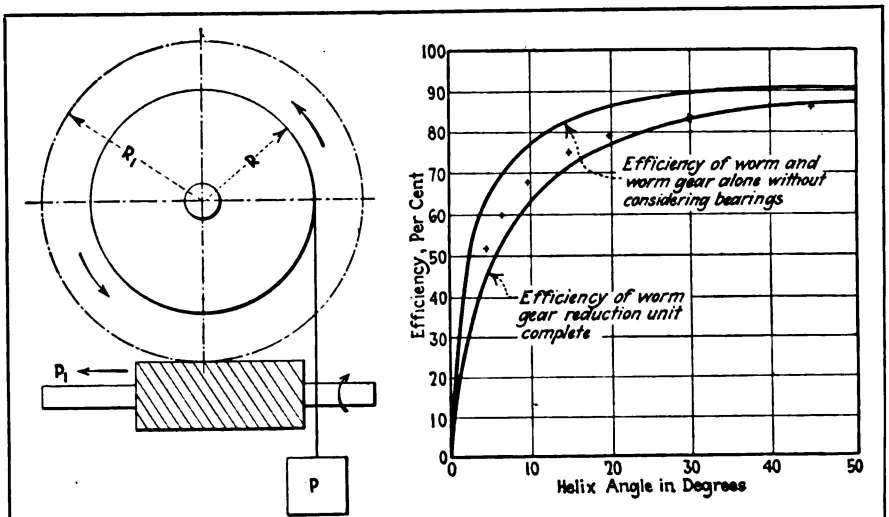
For certain classes of work such as hoists, inclined conveyors, or where the load must be suspended after the power has been shut off, it is desirable to have worm gear speed reducers which are self-locking, to prevent a reversal of the reducer. Where such reducers are required a worm with a smaller lead is necessary. Such a worm may be calculated as follows:

PD = Pitch diameter of the worm gear in inches.
C = Center distance between shafts of worm and worm gear.
P_1D_1 = Pitch diameter of worm.
H = Cotangent of helix angle of worm.
E = Lead in inches of worm thread.
$P_1D_1 = 2C - PD$.
$H = (\pi \times P_1D_1) \div E$.

For a single-thread worm the lead E equals the distance between threads; for multiple worms, multiply this distance by the number of separate

Figs. 2 and 3—Force diagram of worm reducer and worm gear efficiency curves.

The drawing at the left indicates the action of the load on a worm gear and is used in connection with the formulas. The chart at the right shows the relation of the helix angle of the worm to the efficiency. The figures across the bottom of the chart represent the helix angle in degrees. This helix angle is determined by using the accompanying formula and table, as described in the text.

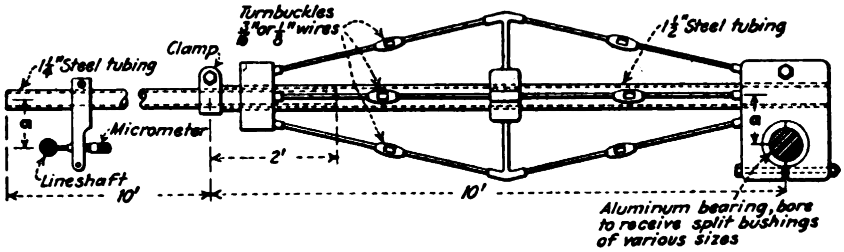


threads. If the angle whose cotangent is equal to H is less than 5 deg. the worm will be self-locking.

Chief Engineer, HARRY C. PETERSON.
Foote Bros. Gear & Machine Co.
Chicago, Ill.

Method of Checking Parallel Alignment of Machines With the Lineshaft

RECENTLY, I had occasion in connection with the installation of a battery of broad drop hammers, each driven by two belts from pulleys at each end of the hammer shaft, to devise some method whereby the alignment of the shafts of the hammer could be made absolutely parallel with the lineshaft.



This device was used to check the distance between the ends of the shafts of broad drop hammers with the lineshaft, to secure perfect alignment.

The bearing at the right is bushed to fit the shaft of the broad drop hammer. The distance to the lineshaft is then measured exactly by the micrometer. The equipment is then moved to the other end of the shaft and the operation repeated. The difference in the micrometer readings shows how much the shafts are out of alignment.

To do this the special gage shown in the accompanying sketch was constructed. This consists primarily of a brace and two pieces of steel tubing, one of which will slide inside the other but still has a close enough fit so that it will not allow any side motion. A clamp permits fastening the two tubes together in any position.

The piece of 1½-in. tubing is 10 ft. long and the piece of 1¼-in. steel tubing, which fits inside of it, is 12 ft. long. There should be a minimum of 2 ft. overlap of the two tubes. When extended to full length, this device may be used to check the alignment of shafts about 20 ft. apart, or it may be shortened up to about 10½ ft. as a minimum distance. These lengths may, of course, be made to fit any special conditions although probably the length indicated above would be the maximum for convenience in handling.

The brace consist of three aluminum castings and four wires or braces with turnbuckles in them. The four-armed spider in the center of the brace may be made either from an aluminum casting, or built up by welding. The ends of the brace were made from aluminum castings, as shown. The large casting at the right is made to clamp around the piece of 1½-in. steel tubing; the bearing which is at right-angles to the steel tubing is bored out to a larger diameter than any of the shafts on the broad drop hammers. Hammer shafts of different diameters were taken care of by using various sizes of split bushings. When in use this bearing is clamped onto one end of the shaft of the hammer.

The casting on the other end of the device holds an inside micrometer, as shown, and is moved along on the tubing until close to the lineshaft and then clamped. It is then possible to make a careful adjustment and measurement of this distance. Additional adjustments for distance may be made by loosening the clamp in the center and sliding the 1¼-in. tubing in the larger tubing.

After taking measurements at one end, the device is then moved to the other end of the hammer shaft and the operation repeated. The difference in the readings of the micrometer shows the amount that the shafts are out of alignment. After the machine is straightened around, the alignment is again checked in the same way. This is repeated until there is no change in the micrometer readings.

Mechanical Engineer, W. W. NICHOLS.
D. P. Brown & Co.,
Detroit, Mich.

Selection of Gears and Pinions for Steel Mill Service

WE HAVE experimented with gears and pinions on cranes and mill motors for a long time. Several different manufacturers' products have been used, many of which have given excellent results. For several years our experiments were confined to pinions which revolved at high speeds, and consequently wore out most frequently. We felt that a worth-while saving could be made, if a satisfactory gear material could be found. About 20 years ago we purchased three so-called tool steel pinions made by the Tool Steel Gear and Pinion Co., Cincinnati, Ohio. These pinions had 14 teeth, 3 diametral pitch, 5-in. face, 2½-in. tapered bore for use on a No. 38-B Westinghouse motor armature shaft. Two of these pinions were installed on the motor drive of the bridge motion of the tilting tables of a structural mill, and the third was used on the ram of an ingot stripper. These pinions were inspected frequently for wear and at the end of six months, when no wear was apparent, more armature pinions were purchased. Although the record of the two pinions on the mill tables was lost, we know that the pinion on the stripper lasted six years, which is about ten times the life of a hard, forged pinion. From subsequent records of the tool steel products we find that this is a conservative average life.

As the manufacturer did not advise or recommend running tool steel pinions into tool steel gears, it was not until 12 years ago, that we tried doing this. By running a tool steel pinion in mesh with the tool steel gear, we get still more service and reap the benefit of longer life of our large motor gears on our many important cranes and machines. Such excellent results were obtained from our motor gears and pinions that for the past ten years we have been using tool steel pinions almost exclusively on the trolleys and bridges of 150 cranes.

We have used certain special, heat-treated gears, also rolled-steel gears, and have found them to give much better service than cast-steel gears. We have tried a special hardening process on cast-tooth gears, cast in our (and other) foundries, but very poor results were obtained. This was probably due to lack of knowledge of how to correctly heat-treat the gears. The hardening was not altogether confined to the teeth, as intended, but got over the shrouds and the ends where it made machining impossible. Quite a number of castings were scrapped on this account. One 14-tooth, 7½-in. face pinion, which was installed on a stripper, ruined the teeth of the rack in a few days. The cause of this was hard, flinty, sharp spots on the teeth, the first evidence of which had been removed by grinding before the pinion was received. This, with the installation of two 17-tooth, 2-in. circular pitch pinions on an open hearth furnace charging machine, which ruined the gear in a short time, ended our experiments with that special hardening of cast-tooth gears.

On constant-speed motors we use common forged steel, tool steel, rawhide, Fabroid, and Bakelite Micarta pinions. Where steel pinions must be used on account of heavy pulls and sudden shocks, tool steel is far superior and more economical than forged steel. Rawhide pinions are very good, and are noiseless, but have a higher initial cost and unless the spares are kept in a damp place they shrink very rapidly in diameter and loosen up in the rivets. A Bakelite Micarta pinion on a gear cutter in the electric machine shop has been in use for seven years and shows very little wear. A steel pinion on this application did not last a year and in addition was very noisy.

Common, open-hearth cast-steel gears can be heated and shrunk onto shafts, giving a very tight fit for hard service, or they can be driven or pushed into place. Tool steel cannot be driven without injury, as the teeth of the pinions will be fractured and the webs of the gears may be cracked. As it cannot be heated except in boiling water, all tool steel pinions are ordered "push fit." No extra care in lubrication is required.

Rawhide pinions require perfect fitting on the shaft and key and are hard to remove after they have been in service for some time. Nothing should be used for their lubrication except a light coat of melted tallow occasionally. Fabroid absorbs oil which may get on it from adjacent gearing or due to carelessness in oiling. Nothing should be used for lubrication of this type of pinion except dry graphite which should be rubbed on the teeth only infrequently, when required.

D. W. BLAKESLEE.
Electrical Engineer,
Jones & Laughlin Steel Corp.
Pittsburgh, Pa.

In the Repair Shop

This section is devoted to repair work on electrical and mechanical equipment. Special attention is given to shop or bench tools and short cuts or improved methods of handling work of this character. Contributions are always welcome.

Changing Phase and Voltage of Turbo-Generator

A LARGE industrial concern bought from a second-hand dealer a turbo-generator whose rating at the a.c. end was supposed to be 625 kva. 230 volts, 60 cycles, three phase. However, when this machine was connected to the line it would not deliver its full rating and would become hot in spots. The manufacturer of the machine was consulted and it was learned that the generator was originally rated at 625 kva., 450 volts, 60 cycles, two phase. The winding had 48 slots, 24 coils, one coil side per slot, being of the bar-and-end-connection type, back pitch 1-and-14, front pitch 1-and-12.

What the dealer had done to make it a three-phase machine was to cut out six coil bars and connect the machine two-parallel star. Eliminating the six bars or three coils caused heating and left 21 active coils in the machine or $21 \div 3 = 7$ coils per phase. As this was a two-pole machine there were two groups per phase and the dealer had put three coils in one group and four in the next and then paralleled the two groups, which resulted in an unbalanced condition, setting up circulating currents. To obtain proper results the six coil bars were put back into service and the following alterations made. The coil pitch was changed to 1-and-12, rear, and 1-and-10, front, the same end connection being used by springing them together for the shorter throw.

The reasoning involved was as follows: For the two-phase, 450-volt winding, the pitch was 1-and-14; then the voltage per phase for three phase equals $(450 \times 2 \div 3) \times (0.955 \div 0.905) = 316.56$ volts for the line voltage of a series-delta connection. But only 230 volts are required. If the stator were connected series-star the line voltage would be $316.56 \times 1.73 = 547.65$ volts and a two-parallel star connection would reduce the voltage to $547.65 \div 2 = 273.83$ which would still be too high and the chord factor would have to be reduced in this case to $230 \div 273 = 0.843$. The span is 180 deg.; full pitch equals 48 slots $\div$ 2 poles = 24 and the chord factor at full pitch or 24 equals 100 per cent which is also the sine of one-half the angle covered by the coil throw. Span at full pitch equals $180 \div 24 = 7.5$ deg. per slot and for a throw of 1-and-14 it would be 13×7.5 or 97.5 deg. The sine of one-half of 97.5 deg. = 0.7509 or the chord factor at 1-and-14. The 230-volt factor must equal $0.7509 \times 0.843 = 0.6330$ which is the sine of 39.3 deg., or the coil throw angle equals 78.6 deg., and the coil pitch equals $78.6 \div 7.5 = 10.5$ slots. Now, when there is only one bar per slot the pitch has to be odd; that is, 1-and-12, 1-and-14, and so on. The 1-and-10 pitch would be too short and the 1-and-12 pitch would give a chord factor of 0.66; this is $0.66 \div 0.75 = 88$ per cent reduction, or the line voltage would be $273 \times 0.88 = 240$ volts, which is only 4 per cent high and will work all right.

The machine was then reconnected two-parallel star, pitch 1-and-12, using all 24 coils, eight coils per phase and four coils per pole-phase group, which worked satisfactorily. A. C. ROE.

Wilkinsburg, Pa.

How to Make a Soldering Iron Heated by a Carbon Arc

BOTH industrial and commercial electric repair shops have a large amount of soldering to do.

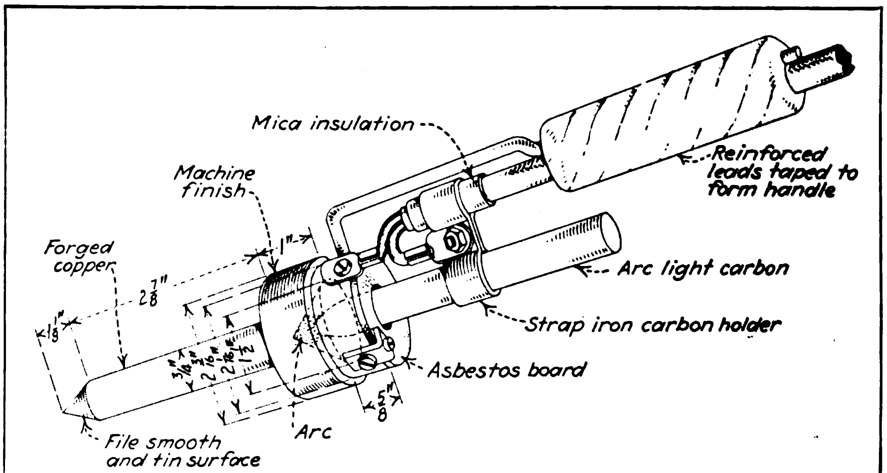
Under these conditions the use of the ordinary soldering iron heated in a furnace or fire pot is rather costly and not altogether satisfactory, as time is lost in waiting for the irons to heat and frequent filing and tinning are necessary. Also, inasmuch as the irons cool off rapidly it is sometimes difficult to obtain a smooth soldering job, so that filing or scraping may be required.

On the other hand, some types of electric soldering irons will not stand continuous operation when kept hot enough to do any volume of work.

The soldering iron shown in the accompanying illustration has been used with good success for a number of years in one of the large steel works in Pittsburgh. The use made of it is mainly for soldering commutators in the armature repair shop. An unusual feature of this iron is that the soldering bit is heated by means of a carbon arc. This arc is held between a carbon electrode and the copper bit itself. The carbon electrode is held in a handle in such a manner that it may be moved forward gradually as it is burned up. The soldering iron requires about 2½ amp. and is fed from a 230-volt, direct-current supply using enough resistance in series with it to hold the current at the value given. The cost of operation to the user when employed in a large industrial works, will be found to be almost nothing.

The soldering bit is made of forged copper and is machined and drilled according to the dimensions shown on the accompanying sketch. It will be noticed that there are three ⅛-in. holes drilled in the rear end of the bit. These are tapped for machine screws. One lead from the power supply is fastened to the bit by means of a machine screw, as is shown in the illustration. A metal support made of strap iron and bent to form a handle is fastened to the copper bit by means of one of the other machine screws. The third machine screw is used for attaching a small strap iron clamp to which is fastened an asbestos board screen which encloses the hollow end of the copper bit so that the eyes of the operator will be shielded from the arc while it is in use.

This soldering iron will stand continuous service and may be operated at an almost negligible cost. It is connected in series with resistance to the 230-volt d.c. power supply and requires a current of 2½ amp. The only materials required to make this iron are a forged copper bit, a ⅜-in. arc carbon, a few pieces of strap iron, some copper wire leads and an asbestos board screen.



One end of a strap iron clamp is attached to the lead connected to the copper bit and the other end of the clamp holds the carbon electrode in the center of the bit, as shown. The second lead from the supply is attached to the strap iron clip. This clip is insulated from the first lead by means of mica insulation. The asbestos board screen has a hole drilled through it that fits around the carbon very loosely so that the latter may be gradually pushed forward as it is consumed by the arc. The two leads, together with the strap iron handle are all taped together so as to make a handle having sufficient strength and balance to give convenient operation. The carbon electrode is an ordinary ¼-in. arc carbon and is held in the clip with only enough friction to prevent any movement while using the iron and yet permit a forward movement of the carbon when the iron is jarred slightly.

Electrical Engineer, D. W. BLAKESLEE.
Jones & Laughlin Steel Corp.
Pittsburgh, Pa.

How to Make Inexpensive Lathe for Banding Armatures

WHEN banding armatures it is common practice in repair shops to use a special banding lathe, or an ordinary lathe with special attachments. However, special armature-banding lathes are rather expensive for shops that do not have to band many armatures, while some of the make-shift devices that are sometimes used do not turn out a satisfactory job.

The illustration shows a very satisfactory banding lathe that was made from an old worm-gear reduction, some structural steel shapes, and a few machined parts. This lathe has an overall length of 7 ft. 11⅛ in., height 3 ft. 10½ in., and width 2 ft. ¾ in. The center line of the armature to be banded was fixed at 3 ft. 2 in. from the floor level. This height seems to give about the right working distance for any armature that the machine will handle. The machine will accommodate an armature whose shaft length does not exceed 5 ft. 8 in. or whose maximum diameter does not exceed 27 in. The armature should not weigh over 1,500 lb., although if the tail stock is kept close to either of the legs, a weight of 500 lb. extra may be safely handled.

Parts *B*, *C* and *D*, the legs, were made from 2½-in. by 2½-in. by ⅜-in. angles. Parts *E*, *F*, *G* and *H*, the horizontal supports for the tail stock and worm-gear reduction, were made from 2½-in. by 3½-in. by ⅜-in. angle iron.

The braces *L* and *M* at the bottom may be made from any small angle iron, such as 1½-in. by 1½-in. by ⅛-in., as they do not bear any of the weight of the machine. The two longer legs, *B* and *C*, were made 2 ft. long while the length of the two shorter legs is governed by the height of the gear reduction, as it is necessary to keep the center of the driveshaft on the gear reduction at the same height as the center of the tailstock screw. The ⅜-in. gusset plates shown as part *A* on the sketch are 6 in. by 6 in., and were cut to fit the angles used. The legs of the angles *B* and *C* were turned in and the gusset plates placed between them and the horizontal members. The construction at the corners may be seen from the sketch. It will also be noted that the longer leg of the horizontal members is used vertically, so as to secure the greatest stiffness.

The tailstock consists of six different pieces, exclusive of nuts, bolts and lockwashers. The sliding support *J* consists of an 8-in., 18¾-lb. channel iron, drilled so that it may be bolted at various distances from the gear reduction, to allow for variation in armature shaft length. Upon it are bolted two L-shaped pieces, *T*, made of ¾-in. by 6-in. steel bar. Block *P*, which carries the tailstock screw, is a block of steel 4 in. by 4 in. by 6 in. tapped for a 1½-in. standard machine bolt. It is also drilled and tapped for bolting to the two L-shaped pieces, *T*, which are in turn bolted to the sliding, channel-iron base. The tailstock screw itself is a 1½-in. machine-bolt, 12 in. long tapered to a center point at one end and hardened. It is also equipped with a crank or handwheel for turning. It is necessary to have a setscrew, *O*, in the tailstock block, and this should be tightened whenever the machine is in use; otherwise the tailstock screw may turn when the machine is running which would either bend the armature shaft or wreck the machine.

A channel, bolted between the two cross-members, supports one side of the worm-gear reduction while the other side is supported by the table angle. The channel may also form a support for one side of the motor base.

All angles and other parts were bolted together, lockwashers being used in all cases. Holes should be drilled 1/16 in. oversize unless unusual care is used in laying them out. Riveted construction is, of course, to be preferred, but bolted construction will give satisfactory results, provided the nuts are turned up tightly. The use of ½-in. machine bolts is recommended for the construction of the framework, while in the tailstock assembly ⅜-in. bolts may be used.

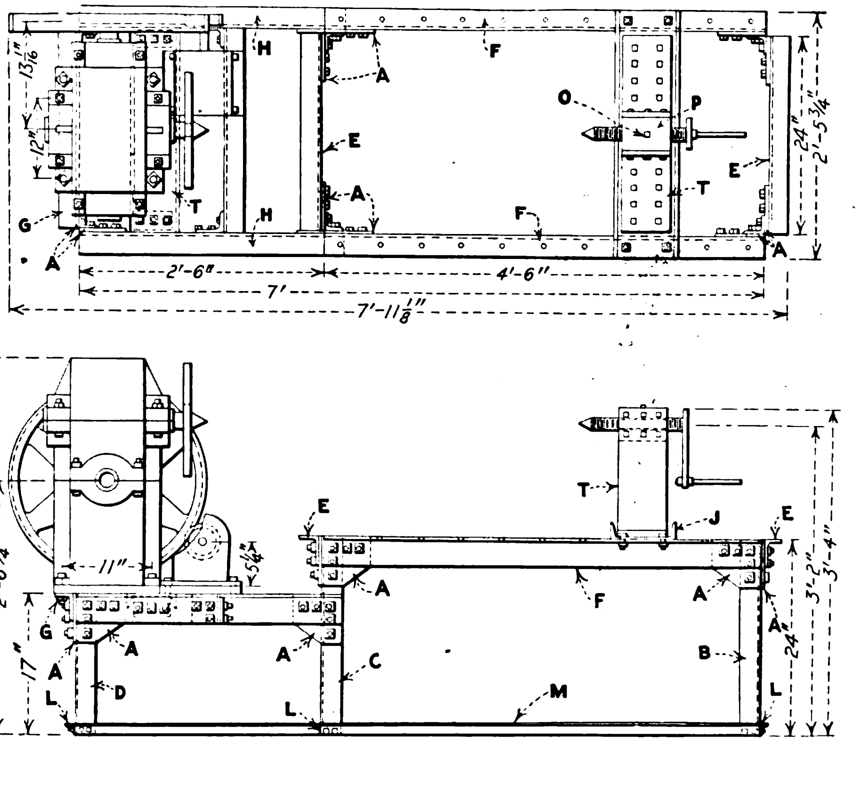
The driveshaft on the gear reduction was turned down at one end and hardened. A keyway was also cut in the tapered end of this shaft, and a slotted faceplate such as is used on a lathe was keyed to it. When banding an armature a lathe dog is fastened to the shaft, the other end of the dog engaging in the slot in the faceplate. A ¾-hp. 1,760-r.p.m., d.c. motor is used on this machine, the speed being cut down by the gear reduction from 1,760 r.p.m. to about 4 r.p.m. A double-pole, double throw, knife switch and starting rheostat were mounted on the machine by means of brackets. It is important that the starting rheostat and knife switch be placed within easy reach of the operator. All moving parts such as gears or live electrical parts should be guarded so that injury to the operator is impossible.

At the present time the banding wire is placed on a reel near the machine and tension is secured by running the wire through two pieces of fiber clamped upon a horizontal member of the machine at the point where the banding is to be done. In winding brake coils or other coils in which insulated wire is used, the wire reel is placed a short distance behind the machine on a rack. The desired tension is secured by hanging a steel wire with weights on each end in the grooves on the reel. The tension may be changed by varying the weights.

The advantages of this lathe are low cost and greater durability and utility than are found in ordinary makeshifts.

Toronto, Ohio. HERBERT KING.

This armature-banding lathe was made from an old worm gear reduction, structural steel shapes and a few machined parts.



New Equipment

for plant operation and maintenance

Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these new devices which are designed to improve plant operation or reduce operating and maintenance costs.

Covered Plug Fuse Cutouts

IN ORDER to meet the demand of various localities which now require the use of dead-front cutouts in place of the old style, in which the terminals are exposed, the Trumbull Electric Mfg. Co., Plainville, Conn., is listing a new two- and four-circuit, covered cutout to meet these requirements. The former is shown in the accompanying illustration. Covers for these cutouts are made of steel, which are backed by an insulating plate with test holes, which permit testing without removing the covers. The test holes are well insulated and in plain sight. The cutouts may be wired for single fusing with two- or three-wire mains, or for double fusing with two-wire mains. It is stated that the screws cannot fall out when the covers are removed for wiring and when the units are arranged in gangs, the screws hold the covers together, which insures pressure connections for grounding purposes. The grooves shown in the side are for the meter connections. The connection to ground is easily determined by location and color. Because the covers extend over the contact terminals, which are recessed in the porcelain, it is claimed that no barriers are required. This type of cutout is made in the 30-amp., 125-volt size.

Elevating Platform Truck

ANNOUNCEMENT is made of a new elevating platform truck, designated as the Yale K 23 E, by the Yale & Towne Manufacturing Co., Stamford, Conn. This truck is designed primarily for heavy loads. Although this machine is not of the high-lift type, such as the Yale K 22, it does embody the self-loading feature. The short turning radius and the narrow width of this machine are said to make it easy to drive in and out of box cars or narrow aisles. Hardened steel steering pivots with bronze bushings and the high-pressure lubricating system reduce friction and make steering easy, it is stated, even when carrying a full load.

The triple spur-gear elevating mechanism consists essentially of the same unit as is used in the K 22 truck, making the major replacement parts interchangeable between models. The elevating platform is raised by means of two large eccentrics mounted on the hoist unit shaft, which draw the platform forward and upward on the platform links. The majority of parts, units and sub-assemblies of this truck are standard and interchangeable with those of all other models in the K series manufactured by the company.

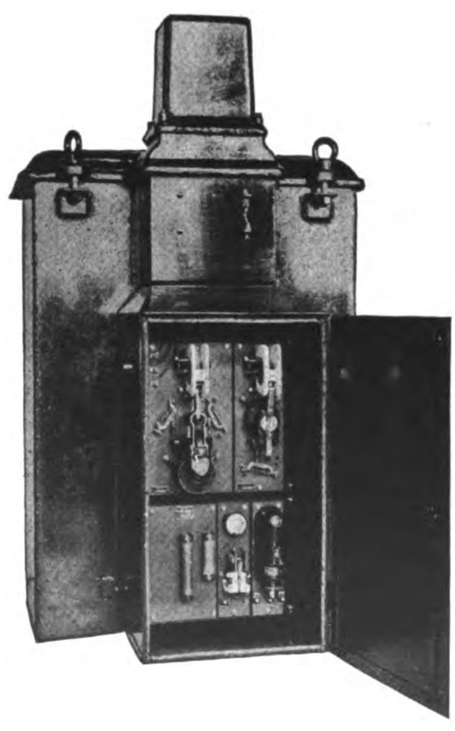
Synchronous Motor Control

DEVELOPMENT of a completely self-contained, oil-immersed automatic starter for 2,300-volt synchronous motors has been announced by the Electric Controller & Manufacturing Co., Cleveland, Ohio. This unit is built for across-the-line starting of slow-speed motors, and for reduced voltage starting of the higher-speed motors. The illustration shows a reduced-voltage type starter. The full-voltage equipment for starting slow-speed motors is of similar appearance except that the height is reduced. It is stated that in each case the operator simply pushes a button to start the motor and as the motor approaches synchronous speed, the field excitation is automatically applied.

According to the manufacturer's description, the reduced-voltage starter consists of a welded boiler-plate tank which contains an automatic, double-throw switching mechanism, a power transformer for providing starting voltage, potential transformers for providing 220 volts for operating the master switch and the current-limit transition relay, which connects the motor to full voltage when it has been accelerated to about 85 per cent of synchronous speed.

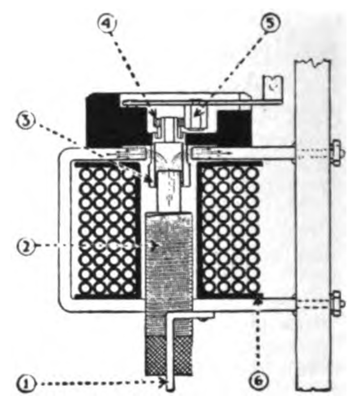
A dustproof steel cabinet on the outside of the tank encloses a field switching mechanism, field discharge resistor, timing relay and d.c. field ammeter. This cabinet may also contain an automatic starter for operating a magnetic clutch. The full-voltage starter is of similar construction except that the starting auto-transformers are omitted.

This equipment is said to be complete in a single unit and makes possible floor-mounting of all equipment required for starting synchronous motors.



Thermal Relay

THE "Inducto-therm" relay, which can be adapted to a wide range of horsepowers without changing the thermal element, has been placed on the market by the Allen-Bradley Co., 286 Greenfield Ave., Milwaukee, Wis. The company is using this relay as the protective unit on some of its standard a.c. switches and starters. The type J-1552 across-the-line starting switches are now available with this new relay incorporated in them.



The operation, referring to the accompanying sketch, is as follows: The motor current flowing through the magnetizing coil, *6*, creates a pulsating magnetic flux in the core, *2*, and this flux induces eddy currents in the thermal element shown at *3*, by transformer action.

If the current flowing through the relay exceeds a predetermined maximum, the magnetic flux in the core becomes sufficiently dense to heat the copper thermal element *3* sufficiently to melt the solder which holds the ratchet wheel *4*. The ratchet wheel then turns and opens the relay contacts.

As soon as the motor current is interrupted the thermal element cools and the solder automatically sets and holds the ratchet wheel ready to repeat its performance. The relay contacts must be reset by hand after the ratchet wheel has again become fixed. The contact mechanism is maintained in a closed position by the reset lever *5*, which engages the ratchet wheel.

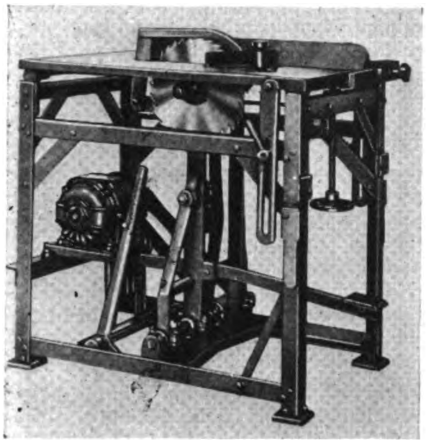
The magnetic core is adjustable and can be raised or lowered according to the scale so as to vary the current at

which the relay will trip. The relay can be adjusted over a range of from 1 hp. to 5 hp. for a given voltage, and all intermediate horsepower ratings can be obtained without changing the thermal element. The same type of relay can be used on larger horsepower ratings of controllers with the same degree of flexibility.

Portable Saw Table

MARKETING of the Wonder portable saw table for use with either cut-off or rip saws is announced by the St. Louis Machine Tool Company, 1429 Pine St., St. Louis, Mo.

The portable saw unit that is shown



in the accompanying illustration is operated by a 1-hp., ball-bearing, 1,750-r.p.m. motor. This motor is of the semi-enclosed type and can be furnished for operation on either direct current or single-phase alternating current at 110, 220, or 440 volts, 60 cycles. If desired, a 1-hp., 1,750-r.p.m., 1-cylinder, 4-cycle gasoline engine may be supplied in place of the motor.

The table top is made of cast iron, while the frame is constructed of angle irons bolted together. The motor or gasoline engine is bolted to a jackshaft which, in turn, is belted to the saw through an idler pulley. The entire saw unit is pivoted at the base around the center line of the jackshaft and by means of a foot-controlled lever the saw is swung through an arc and thus advanced through the work which is held stationary.

Brass Cups for Traffic Markers

MARKERS for aisles and traffic lanes in industrial plants, as well as for street service, have been developed recently by the Bridgeport Brass Co., Bridgeport, Conn. These consist of round brass cups which are driven into the floor or pavement or set into new floors and pavements. These traffic markers are made in two diameters, 3 in. for pedestrian markings and 4½ in. in diameter for heavy traffic lines. The manufacturer states that these are highly visible, easily inserted and require no upkeep. They may be inserted in asphalt, macadam, wood block, Amasite, Warrentite, new concrete work and other similar materials.

Primary Resistor Starter

REVERSING primary resistor starters for squirrel-cage induction motors have been announced by the General Electric Co., Schenectady, N. Y. Two three-pole line contactors are provided with this starter, which is designated by the style number CR-7055-A-1.

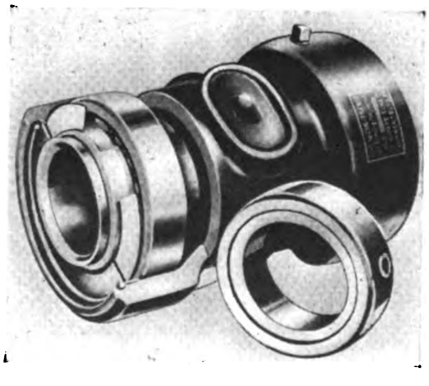
These contactors are electrically and mechanically interlocked and are mounted back-to-back on the panel. A magnetic time interlock provides a predetermined definite time of from one to three seconds between the closing of the line contactor and the accelerating contactor.

Two-point starting is provided by a resistor designed to confirm to Electric Power Club classification No. 16. A temperature overload relay with an external resetting mechanism furnishes overload protection. The inclosing case is of sheet metal, semi-ventilated, and is provided with feet for wall mounting. When mounted, the panel occupies a position at right angles to the wall. Doors are provided at back and front.

Ball-Bearing Hanger Box

ADOPTION of the Fafnir bearing as an incorporated part of its own line of transmission equipment has been officially announced by the T. B. Wood's Sons Co., Chambersburg, Pa. Fafnir ball bearings have been used in "U.G." hanger boxes, Wood's loose pulleys and friction clutches for many years, but they are now adopted as a standard part of the entire Wood line of power transmission equipment. The most recent addition has been the Wood-Fafnir hanger box which is shown in the accompanying illustration. The housings are made in several styles with bosses designed to suit the different types of hanger frames that are of standard manufacture.

The manufacturer states that plain or babbitted bearing boxes can be replaced without removing the present hanger frames and that the Wood-Fafnir ball-bearing hanger box needs no adjustment when mounting on the shaft as it is necessary simply to slide the box and the two locking collars to place on the shaft and into the frame, then draw up the frame bolts and tighten the collars. It is also stated that the hanger box is dustproof and leakproof. Lubricant is supplied through two tapped holes which are fitted with standard pipe plugs and,

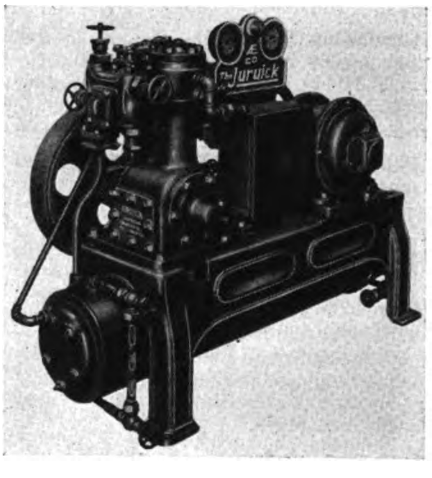


according to the manufacturer, lubrication is generally necessary only twice a year.

It is the purpose of this company to make not only ball-bearing hanger boxes, but also ball-bearing post hangers, pillow blocks, loose pulleys, and friction clutches: in fact, a complete line of ball-bearing-equipped transmission machinery.

Automatic Refrigerating Unit.

THE American Engineering Co., Philadelphia, Pa., announce an improved, self-contained, automatic, 2-ton refrigerating unit as an addition to the Juruick line. This unit, which is shown



in the accompanying illustration, is especially designed for automatic operation and includes a motor, compressor, condenser, and ammonia storage tank compactly mounted on one base and provided with all necessary controls. A 3- to 5-hp. motor is provided, according to conditions. This unit may be used for factory lunch rooms, circulating water systems, or other industrial applications within its capacity.

Light-Weight Welding Torch

FOR work not requiring the usual standard torch, The Alexander Milburn Co., Baltimore, Md., has perfected a small, type J-Jr., light-weight welding torch. This is said to be a sturdy, compact torch giving a high degree of efficiency and economy. The torch uses the same tips as are supplied with the standard larger torches and, according to the manufacturer, is adaptable to all classes of welding. It uses low and approximately equal pressures of oxygen and acetylene.

The J-Jr. torch is adapted to gas supplied either from generators or compressed in tanks. The torch is made of bronze forgings and drawn stainless tubing. It is said to be simple in construction, with all parts easily accessible and the head set at an angle of 67½ deg.

The manufacturer states that this torch is well balanced, is easily manipulated and will not tire the operator. The J-Jr. is 18 in. long, weighs 25 oz., and is furnished with three welding tips adaptable to a wide range of welding.

Trade Literature

you should know about

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Tape—A number of circulars describe each of the various types of tape for different uses put out by this company. —The Okonite Co., Inc., Passaic, N. J.

Water Softener—Bulletin 509 illustrates and describes the Graver Zeolite water softener.—Graver Corp., East Chicago, Ind.

Grounding Condulets—Folder 39 and bulletin 2089 illustrate and describe the Crouse-Hinds condulets for grounding service wires in conduit systems.—Crouse-Hinds Co., Syracuse, N. Y.

Balancing Device—Treatise No. 2 discusses the Gisholt method of balancing armature shafts, pulleys, crankshafts for gas engines and numerous other high-speed rotating parts.—Gisholt Machine Co., Madison, Wis.

Slate—A circular, which is accompanied by a sample, discusses the merits claimed for Monson slate in electrical, chemical and structural uses.—The Monson Maine Slate Co., 112 Water St., Boston, Mass.

Fire Extinguishers—A circular describes the Rego Fire Stopper which is a portable, non-liquid fire extinguisher said to be particularly adapted for protection against fires in oils and flammable liquids.—The Bastian-Blessing Co., Chicago, Ill.

Acetylene Generator—A circular announces a reduction in prices on all sizes of Smith's automatic acetylene generators in portable and stationary types.—Smith Welding Equipment Corp., 2633 4th St., S. E., Minneapolis, Minn.

Welding Rods—A 24-page booklet entitled, "Effect of Surface Materials on Steel Welding Rods," stresses the advantages of Weldite welding rods for gas and electric welding.—Chicago Steel & Wire Co., 103d St. and Torrence Ave., Chicago, Ill.

Motor Control—A series of bulletins entitled "Mill Motor Gossip" describes in an interesting manner the lines of new equipment brought out by this company and the work they will do. The description is brought out in an imaginary conversation carried on between the various mill motors.—The Clarke Controller Co., 1146 E. 152d St., Cleveland, Ohio.

Static Condensers—Leaflet 20,286 discusses the application, construction and installation features of static condensers for power factor correction on motor circuits of 220, 440 and 550 volts. A table gives the corrective kva. for various ratings of three-phase, 60-cycle, type, CS squirrel-cage induction motors ranging from ½ to 200 hp.—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Watt-Hour Meters—Bulletin 71 contains instructions for the installation, operation and maintenance of the Sangamo type D-5 watt-hour meter.—Sangamo Electric Co., Springfield, Ill.

Centrifugal Oil Purifier—A six-page circular describes the De Laval method of purifying transformer and switch oil.—The De Laval Separator Co., 165 Broadway, New York, N. Y.

Car Spotter—A circular describes the Caldwell vertical-capstan car spotter which is made in two sizes operated by 5-hp. and 10-hp. motors and with capacities up to three or six cars respectively.—H. W. Caldwell & Son Co., 1700 S. Western Ave., Chicago, Ill.

Compression Clutch—Bulletin 35 describes the Conway compression clutch which is made as a clutch, clutch coupling and clutch pulley for transmission work as well as for machine application.—The Conway Clutch Co., 1935 W. Sixth St., Cincinnati, Ohio.

Conveyors—A circular describes the Stearns carriers, idler pulleys, and return rollers for belt conveyors and their methods of lubrication, as well as the Holotile storage bin for coal and other loose material.—The Stearns Conveyor Co., E. 200th St. and St. Claire Ave., Cleveland, Ohio.

Graphic Meter—Bulletin 525 describes and illustrates the equipment, operation and application of the Esterline-Angus quick-trip graphic meter which speeds up the drive automatically whenever trouble occurs and automatically returns to normal speed at the end of the disturbance.—The Esterline-Angus Co., Indianapolis, Ind.

Wire Rope—The May issue of "The Yellow Strand," a monthly house organ, celebrates the occasion of the 50th anniversary of this company, giving its history, a description of the plant and numerous illustrations of applications of Yellow Strand wire rope.—Broderick & Bascom Rope Co., 801-809 N. First St., St. Louis, Mo.

Refractory Gun—A circular describes the use of a Quigley refractory gun for making quick repairs in the maintenance of furnace linings, as well as for industrial plastering and stuccoing.—Quigley Furnace Specialties Co., Inc., 26 Cortlandt St., New York, N. Y.

Motors — Circular GEA-6 describes the G.E. squirrel-cage motors of the 500 series. Circular GEA-71 describes the types MT and MQ wound-rotor induction motors of the 900 series for constant or adjustable varying speed. Circular GEA-246 describes the general-purpose synchronous motor of the 7500 series.—General Electric Co., Schenectady, N. Y.

Diesel Engine—Bulletin 707 describes the Foos type L Diesel engine units which are made with two to eight cylinders, with a power range of 50 to 475 hp., and in speeds up to 900 r.p.m.—The Foos Gas Engine Co., Springfield, Ohio.

Magnetic Brake—Bulletin 102 describes the Clark Three-C magnetic brake for use with series or shunt-wound direct-current motors on cranes and similar applications.—The Clark Controller Co., 1146 E. 152nd St., Cleveland, Ohio.

Oil Engine—A 32-page catalog illustrates and describes the application, construction and operation of the Ingersoll-Rand type PO direct-ignition oil engine—Ingersoll Rand Co., 11 Broadway, New York, N. Y.

Portable Recording Instruments—Bulletin GEA-304 describes the construction and operation of type CP-4 and CP-5 portable recording instruments for direct and alternating current.—General Electric Co., Schenectady, N. Y.

Conveying Equipment—A circular describes some of the screw and bucket conveyors manufactured by this concern and gives particular attention to the lubricated gear countershaft box end for helicoid and sectional flight screw conveyors.—H. W. Caldwell & Sons Co., 1700 South Western Ave., Chicago, Ill.

Tramrail Systems—An eight-page circular describes and illustrates the use of Cleveland hand and electric tramrail systems for handling waste paper in bales in storage and in paper mills. Another circular describes applications of similar equipment in rubber mills.—The Cleveland Electric Tramrail Division of The Cleveland Crane & Engineering Co., Wickliffe, Ohio.

Portable Power Shear—A circular describes the Unishear which is a motor-operated, portable shear for cutting flat sheets up to 14 gage steel and 12 gage soft metal at a speed of 15 f.p.m. This shear may be used on either straight or irregular cutting of gaskets of any material, as well as sheet metal for guards or ducts.—The Unishear Co., Inc., 170 5th Ave., New York, N. Y.

Pneumatic Tools—Catalog 15 describes the complete line of Thor pneumatic drills, hammers, chisels, hoists and other tools, together with instructions for their maintenance.—Independent Pneumatic Tool Co., 600 W. Jackson Blvd., Chicago, Ill.

Inserts—A circular describes a type of Truscon insert for placing in concrete forms before pouring, to provide a means of attaching fixtures, such as sprinkler systems, plumbing and heating equipment, and suspending shaft-hangers, tramrails and other equipment from the ceiling.—Truscon Steel Co., Youngstown, Ohio.

Fuswitches and Disconnecting Switches—Bulletin 501 gives a complete description of the Matthews equipment in various ratings, discusses safety factor, rupturing capacity, flashover, construction, and other important details. —W. N. Matthews Corp., 3718 Forest Park Blvd., St. Louis, Mo.

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Layout of Distribution System

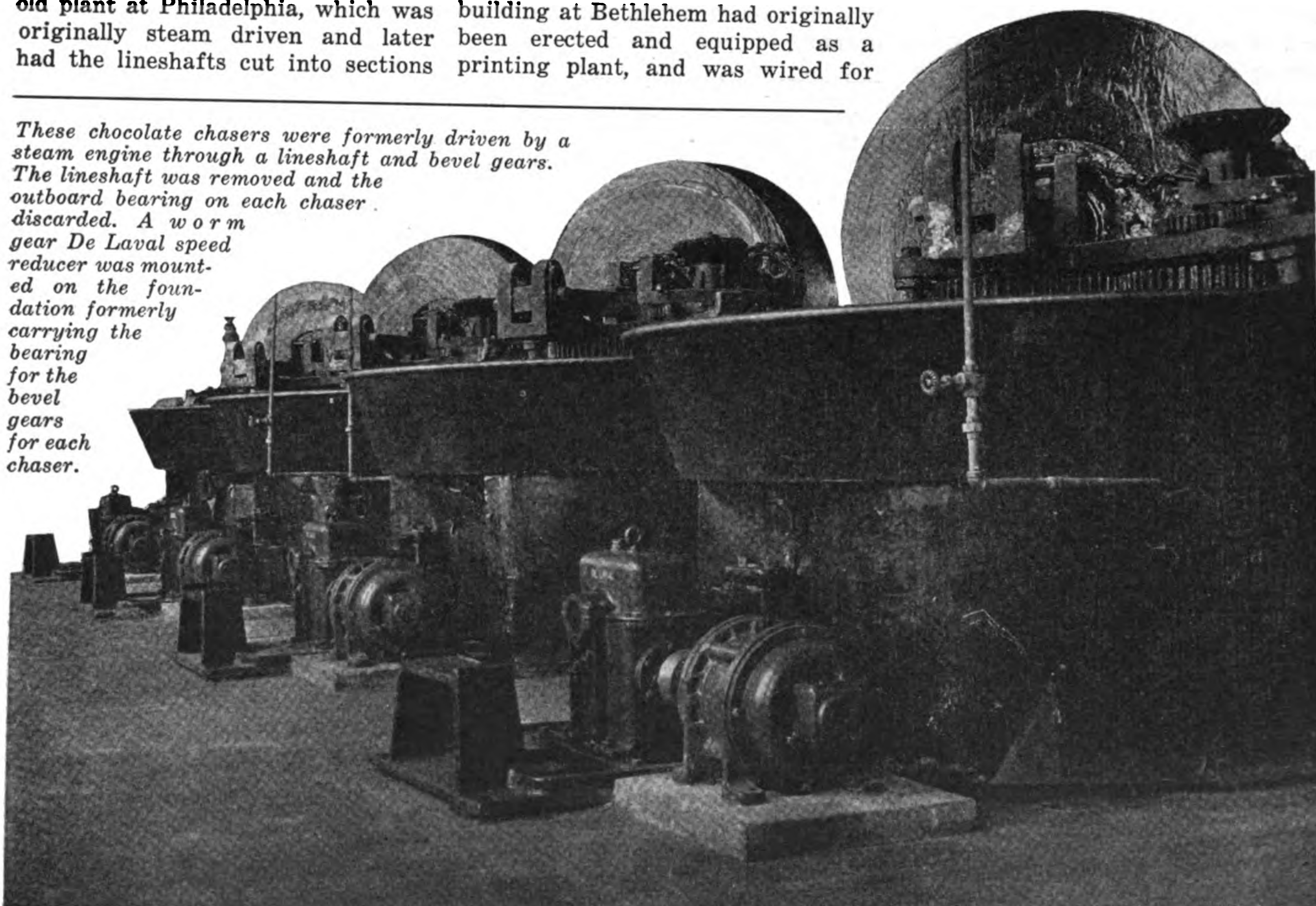
and Power Drives in a Small Factory

THIS article gives the details of the new power drive installation in a factory using 188 motors. The wiring layout is described, following which is a discussion of the types of motors selected, kind of control required, and the arrangements provided for connecting the motors to the machines driven by them.

By J. L. MERRILL

Consulting Engineer, Philadelphia, Pa.

ELECTRIFICATION of the candy factory of Croft & Allen, Inc., presented a number of interesting problems. In the first place, their old plant at Philadelphia, which was originally steam driven and later had the lineshafts cut into sections driven by 115-volt d.c. motors, was to be discontinued and the same candy-making equipment was to be moved to their new plant at Bethlehem, Pa. In the new location all of the machines were to be individually driven by motors. The new plant was a one-story building, being a radical departure from the accepted type of modern, candy-making plants. This in itself involved the working out of quite a few new ideas. The building at Bethlehem had originally been erected and equipped as a printing plant, and was wired for two-wire, 220-volt, direct-current, power service. Inasmuch as it was desired to use three-phase, alternating current motors changing of the wiring presented several interesting problems. In addition, the changing over from group drive to individual drive developed several interesting angles in the selection of the proper method for connecting the motors to their driven machines. An interesting result of the change from group to individual drive was that the total horsepower installed was



These chocolate chasers were formerly driven by a steam engine through a lineshaft and bevel gears. The lineshaft was removed and the outboard bearing on each chaser discarded. A worm gear De Laval speed reducer was mounted on the foundation formerly carrying the bearing for the bevel gears for each chaser.

considerably less than was the case with the old group drives. There were several good reasons for this, however.

The building at Bethlehem, Pa., was of the brick and steel type arranged as shown in the diagram on this page. Inasmuch as it was intended for operation as a printing plant, the power wiring was for two-wire, 220-volt, direct-current service. In this installation power was purchased at 13,000 volts, three phase, and transformed to 250 volts, direct-current, by means of transformers and rotary converters. The power for lighting was stepped down to 115-230 volts by means of a 100-kva. transformer.

The old distribution switchboard was located in the center wing of the building, as shown at *H* in the diagram on this page, and consisted of four panels, one a.c. lighting panel having circuits to the various lighting distribution cabinets and three d.c. panels having two power circuits on each, or a total of six power circuits. These six power circuits terminated in six power distribution panels located in cabinets. Four of the power distribution panels are in the main building, about half way from the center to the wing at either end on each side of the building, as shown at *A*, *B*, *C* and *D* of the diagram. A fifth circuit runs directly to *F* which is located in the section built out from the center of the main building opposite the machine shop. In this section are the office and two wings, one now used for a restaurant and rest room, and the other for the printing shop and box storage, as is shown in the diagram. The sixth circuit runs to *E* as shown in the diagram, and serves the machine shop. The circuits running to *A*, *B*, *C* and *D* are composed of two 500,000-circ. mil cables each, while the circuit to *E* in the machine shop is composed of two No. 6 cables, and the circuit to *F* is composed of two No. 0000 cables.

The conduit arrangement was very simple indeed. Five 4-in. conduits were taken from the trench back of the main switchboard at *H* to pull boxes located just inside of the wall of the main building, as shown at *G* in the diagram. These pull boxes were filled with pothead compound so as to insure their being kept dry and free from dust. Two of the conduits were then carried either way in the floor along the wall to the distribution cabinets halfway down the room, at *B* and at *D*. The remaining three conduits were carried directly across the room to pull boxes on the opposite wall as at *J* in the diagram. From this point conduits were carried each way along the walls to *A* and *C*, at which the power distribution cabinets are located. The remaining conduit was carried to *F*, to a power distribution cabinet supplying that wing of the building. The conduit run to the sixth power distribution cabinet at *E* was a separate run from the switchboard trench direct to the distribution cabinet in the machine shop.

Each power distribution cabinet controls four circuits, which are carried in conduits in the floor at the foot of the walls of the building. For example, the power distribution cabinet at *B* has two circuits running each way along the wall from it. On each of these circuits were placed three or four junction boxes at the floor level, which are spaced 15 ft. apart. From each of these junction boxes a circuit was run up the wall to a fuse box after which the circuit goes to the control for the individual motors on that circuit.

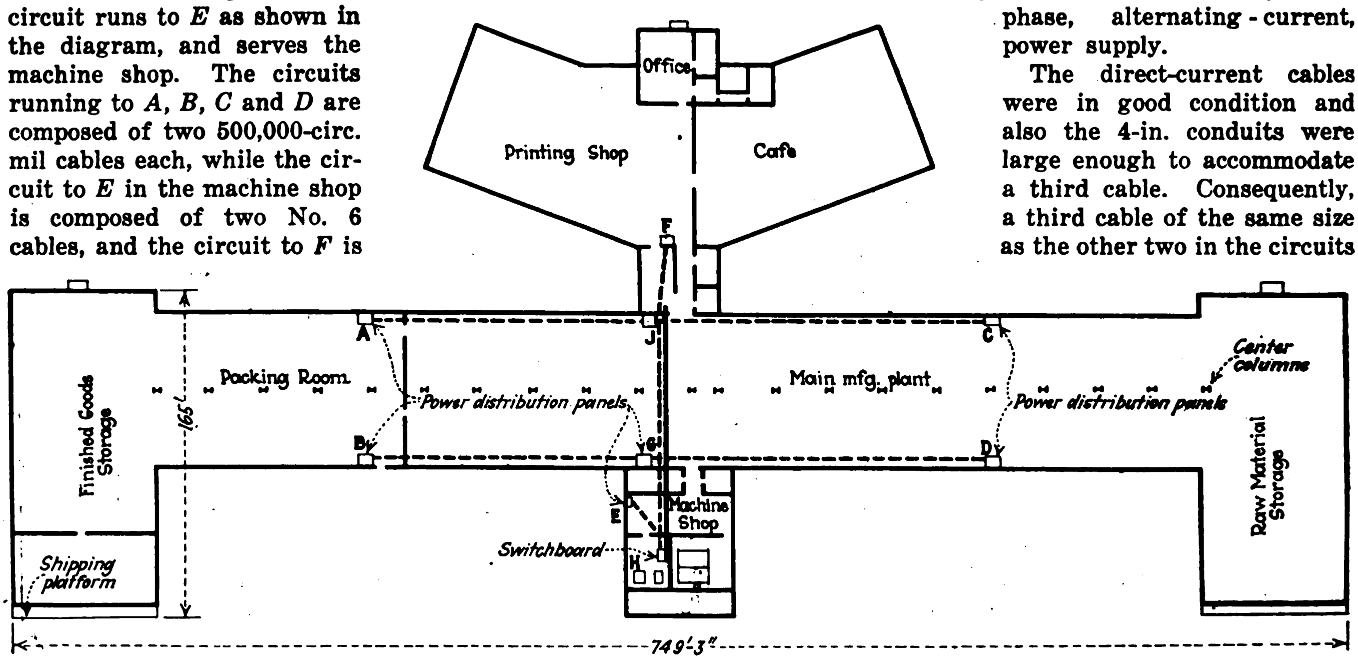
In the illustration on page 395 is shown four control cabinets surrounding a fuse box. A conduit can be seen running from the fuse box in the center to the floor. At this point in the floor is one of the junction boxes just mentioned. These junction boxes are made of iron with a heavy iron cover and are filled with pothead compound. The cover is supposed to be made water tight by the use of rubber gaskets and although these were not used in every case, the pothead compound is relied upon to keep the moisture entirely out of the box. From the fuse box shown in this illustration the circuits are carried to the four magnetic controllers that are mounted in the sheet-iron cabinets, and from these controllers conduits go down the wall and through the floor to the individual motors.

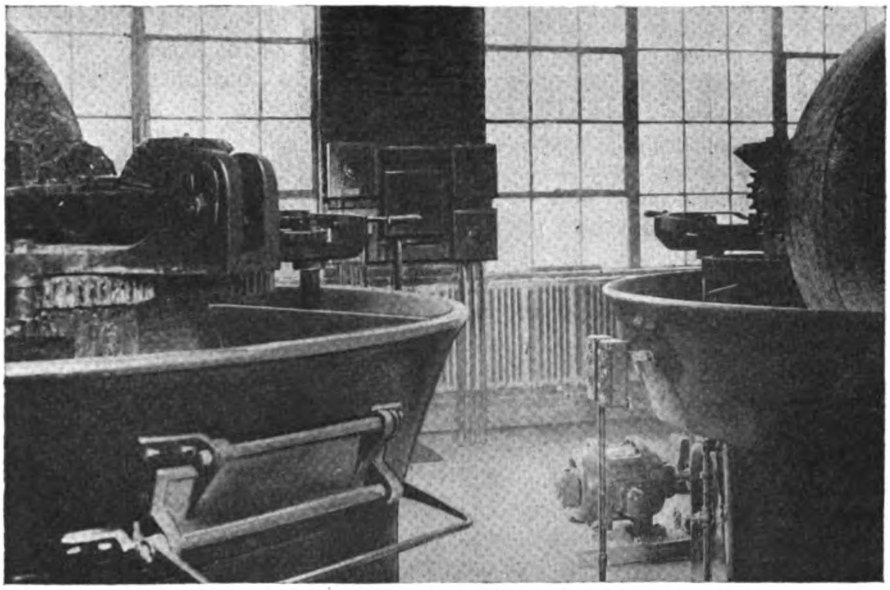
Inasmuch as practically all of the drives are constant speed it was decided that it would be preferable to use a three-phase, alternating-current, power supply instead of the 220-volt, direct-current supply that the wiring in the building was originally laid out for. By drawing a third wire into each of the circuits that have been described in the foregoing, the wiring could be changed for use on 220-volt, three-phase, alternating-current, power supply.

The direct-current cables were in good condition and also the 4-in. conduits were large enough to accommodate a third cable. Consequently, a third cable of the same size as the other two in the circuits

The power distribution layout in this plant is very flexible.

There are six feeders running to distribution cabinets as shown. From each of these cabinets four circuits are run along the wall so as to enable extensions to be quickly run to any location. Junction boxes were located every 15 ft. from which extensions are carried up the wall to a fuse box, thence to the controller, and then to the individual motor.





Individual motor drive greatly simplified the control of these chocolate chasers.

Push button stations controlling the across-the-line starters shown in the center background, give quick control of the machines. The center cabinet is the fuse box and surrounding it are four across-the-line starters for the double squirrel cage motors driving the chasers. On the floor directly beneath the fuse box is a junction box that connects with one of the power distribution cabinets shown in the layout on page 394.

running to the four panels in the main building, that is, circuits to the distribution cabinets, *A*, *B*, *C* and *D*, was pulled in. Also a third wire was pulled in for the circuit running to the distribution cabinet at *E* in the machine shop. Three-wire distribution panels were substituted for the two-wire panels in the steel cabinets at *A*, *B*, *C*, and *D* of the main building. The small panel in the machine shop at *E* was easily changed from two-wire, four-circuit, to a three-wire, two-circuit panel.

All of the distribution panels except that in the office wing were well located for the present purposes. It was not definitely known what the machinery layout was to be when the installation was started so the branch circuits running from the distribution centers were equipped with the extra wire only as they were required. It soon developed that the concentration of load at the center of the building was beyond the capacity of the existing circuits, so the four-circuit, 500-amp., two-wire panel in the office wing at *F* was changed to a two-circuit, 400-amp., three-wire panel, and installed on this circuit at the first pull box in the main building, that is, at *G*. This gave plenty of capacity at the center of the building, which was the point at which trouble was expected.

It was also necessary to change the main switchboard from two-wire, d.c. panels, to three-wire, a.c. panels. Three new panels were substituted for the three panels formerly used.

There are 188 motors in the plant, giving a total connected load of 550 hp. The largest motors in the plant are two 50-hp., synchronous motors which drive ammonia compressors, and one 20-hp., wound-rotor induction motor which gives variable speed on a fan drive. A great many fractional horsepower motors are used. In fact the average horsepower obtained by dividing 550 hp. by 188 is slightly under 3 hp. With the exception of the two synchronous motors, the 20-hp., wound-rotor motor and four, 5-hp., wound-rotor motors, all of the motors are of the squirrel cage type. It was necessary that new motors be purchased, for the motors in the old plant were suited only for a 115-volt, direct current supply, while the power supply at the new plant is 220 volts, three phase alternating current.

In order to avoid the use of compensators and to take care of the extremely high starting torque required by a great many of the machines, practically all motors of 5 hp. and larger are of the double squirrel-cage or FTR type manufactured by the General Electric Co. Where a very high starting torque was required on some of the 3 hp. drives the type FTR motors were also used. The experience obtained on these drives using FTR motors for heavy duty service would have justified their use in a great many of the applications where only 1- and 2-hp. motors were required. However at the time of purchasing these motors the small sizes of motors of this type could not be obtained.

The type FTR motor is a double squirrel cage motor that can be thrown directly across the line without reduced voltage obtained by means of a compensator or starting resistance. It has a starting torque of 250 per cent with a maximum running torque of 200 per cent of full-load torque. The motors therefore come up to speed quickly with peak current values of short duration. The starting current is within the N.E.L.A. rules without the use of a compensator or primary resistance starter. This motor is in general suitable for applications requiring a constant speed and high starting or accelerating torque. It is thrown directly across the line and therefore the control for it is very simple. The control may be either automatic, push-button control, or semi-automatic control.

All of the type FTR motors in use in this plant have a synchronous speed of 1,200 r.p.m. Motors of this speed were used so as to keep the power factor and efficiency as high as possible. For the smaller drives, that is those requiring motors of 3 hp. and less, the type KT, General Electric motor was used. The majority of these had a speed of 1,200 r.p.m., although a few had a synchronous speed of 1,800 r.p.m. On certain operations it was necessary to have variable speed and on these drives type M, General Electric, wound-rotor motors were used. The control for these provided for 50 per cent speed reduction, the standard manually-operated, resistance-type starter being used.

On account of using the double squirrel cage motors the control for the various drives was greatly simplified. Across-the-line starters are used for all of the squirrel cage motors. On the motors below 3 hp. in capacity the type CR 7005 starter was used while the motors above 3 hp. use the type CR 7006 starter, both types being manufactured by the General Electric Co. These two starters consist of a three-pole magnetic contactor equipped with momentary contact, push button stations, and undervoltage protection. Aside from the difference in capacity, the two types differed in that one has a thermal overload cutout while the other has a resetting circuit breaker. The starters are enclosed in steel cabinets and are arranged

on the wall as shown in the illustration on page 395. In this manner the contactor panels were assembled along the walls where the fuse cutouts were located. These locations are comparatively free from the sticky dust characteristic of a candy factory. The push button stations are located at the machines thereby giving quick control of the operation of the machine. The control buttons are small and do not take up valuable space or get out of order easily.

On the smallest motors, including the fractional - horsepower motors, snap switches were used to a great extent. The control for the wound-rotor motors is of necessity special in that variable speeds are involved. Likewise, special controllers were required for the 50-hp., synchronous motors. On the chocolate chasers special three-point push button stations were used as shown in the illustration on page 395. These push buttons provide a start button, a jog button, and a stop button. About ten of these push buttons were used altogether.

As was explained previously, the candy making equipment used in this factory was taken from the old plant at Philadelphia. The old plant was originally engine driven from a series of lineshafts on the different floors. Later in its history the line shafts were cut up into sections and group drive, 115-volt motors were used. At the time of transition from the old plant to the new plant, which was also the time of changing from group drive to individual drive, quite a few tests were made to determine the size of motors as far as possible and primarily to determine the total power that would be required from the public service company. Tests in the old plant in Philadelphia indicated that a considerable portion of the load was lineshaft losses. Because the only power tests that could be made in the old plant were on the motors driving the lineshaft operating various machines, the power actually used by the machines individually could not always be determined very satisfactorily. Also the mechanical condition of some of the older machines was very poor. Cast-iron bearings seemed to prevail and most of them were badly worn. As a matter of fact after the final installation of new motors had been made in the new plant, it was found that 375 hp. of individual motors was carrying the load formerly handled by 603 hp. in group drive motors. On account of the condition of the old equipment it was impossible to use gears or couplings to connect the motors to the drives. It was decided that silent chains or roller chains would be the best solution of the power drive problem, in changing to individual drive. Putting the chains in oversize would lengthen their life if the machines were properly motored on the first trial, and also they would not have to be changed if the motor size had to be increased.

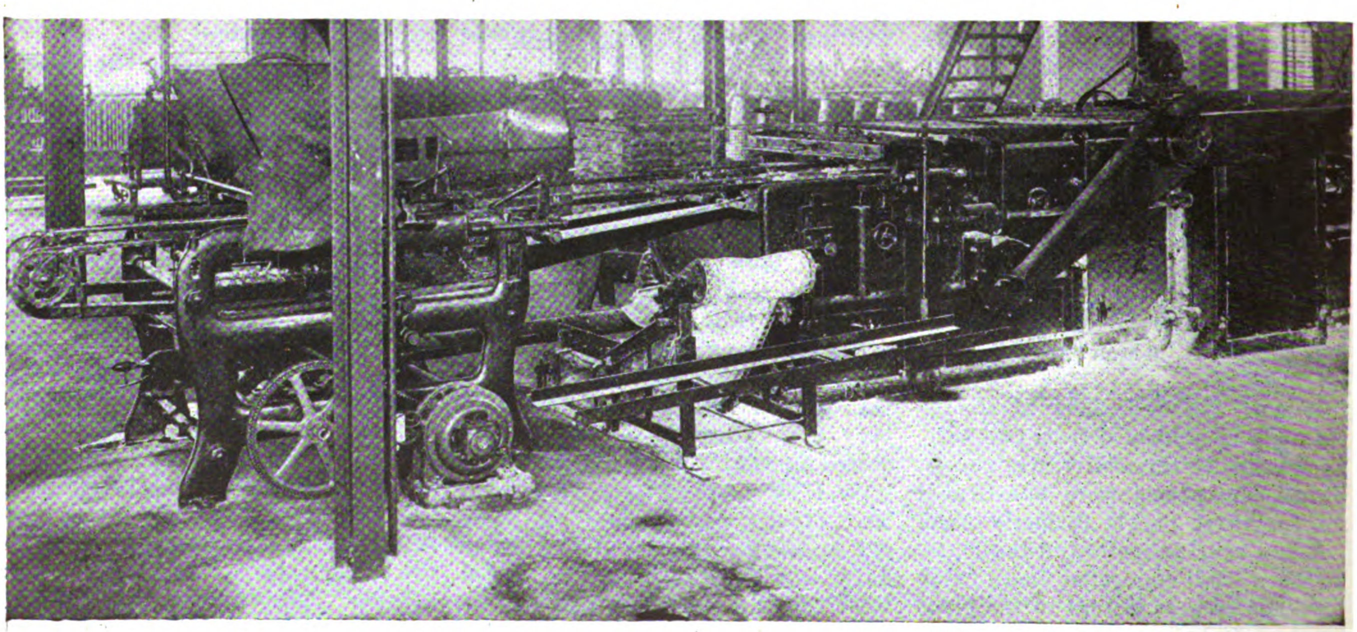
Silent chains are used for connecting most of the motors to their driven machines.

Inasmuch as all of the equipment was originally arranged for driving from a steam-engine-driven lineshaft, it was rather difficult to obtain motor speeds suitable for connecting motors directly to the machines. Also, in many cases mounting the motors so as to couple directly was sometimes difficult. Use of silent and roller chains provided a very flexible arrangement for connecting these machines for individual drive.

In general individual drive was used throughout the plant. However it was found that some of the cooking kettles and polishing pans would require such a low speed that a double reduction would be necessary. Further investigation showed that these drives could be very conveniently grouped. A double reduction chain drive was used, the high speed reduction being made by means of a silent chain and the low speed by a roller chain. Where these groups are used, the countershaft is carried underneath the frame work supporting the kettles or pans, and the resulting drive is simpler and more compact than individual double reduction drives would have been.

A few back-geared motors were used with roller chains from the slow-speed shaft to the machine. However, it was found that a double chain or standard, silent gear reduction or speed reducer was somewhat less expensive and very much more satisfactory than the back-geared motors originally thought necessary. Hence the first lot of these which included three 3-hp., and four 1½-hp. motors were the only ones used.

The illustration on this page shows a typical installation of chain drives. At this point it might be stated that all of the silent chains are of Link-Belt manufacture. This illustration shows a Mogul and Depositor. The Depositor is driven by a 1½-hp., 1,200-r.p.m. motor through a chain drive. This motor is on the floor at the left of the illustration. The Mogul is driven by a 1-hp., 1,800-



r.p.m. motor mounted on top of the machine as shown at the right of the illustration. The shaft that carries the silent chain gear on the Depositor formerly carried a tight and loose pulley with a belt shifting mechanism operated by a lever on the opposite side of the machine. The Mogul was formerly controlled by another belt-shifting mechanism which was operated by the Mogul tender on signal from the operator at the Depositor. Both motors are now controlled together or individually by means of push button stations located at the operator's station on the opposite side of the Depositor from the motor which drives it. Only one man is required to control the two motors. Provision is also made for one or more emergency stop buttons which are within convenient reach of any other tenders of the Mogul.

The only places where belts are used in the plant are on a fan in the machine shop, and on the chocolate enrobers, where the standard drives furnished by the manufacturer of the machines are used.

Worm gear speed reducers made by the De Laval Company are used for obtaining the proper speed. The speed reducers are connected to their motors by Lipe flexible couplings. These couplings have had considerable effect in relieving the shock of the quick start on these drives. These drives are illustrated on page 393. These chasers were originally driven from a countershaft, and the pedestal for the outboard bearings for the shaft carrying the bevel pinion and the tight and loose pulleys was not removed. This outboard bearing pedestal may be noted on the outside of the bedplate carrying the De Laval speed reducer. The reduction in the worm gear speed reducer is from 1,140 r.p.m. to 90 r.p.m. The illustration on page 395 shows the control used on the chasers. A push button control station is located right at the chaser, as is shown in the center of the illustration, and magnetic across-the-line starters are mounted at the wall. This layout of control is typical of that used throughout the plant. The two controllers at the left of the illustration control the motors driving the two chasers shown in this illustration. The two push button stations on the chaser at the right form the control point for these two chaser motors.

The lighting circuits which were originally laid out for three-wire, 220-110 volt, alternating-current, did not have to be changed. The power is obtained from the present power transformers. The 110-volt tap on one of the present transformers is brought out to provide the center wire of the three-wire system.

The engineers of the local public service company went over the old plant in Philadelphia and estimated that the new plant would use about 45,000 kw.-hr. per month on a minimum demand of 200 kw. However, tests in the old plant indicated that a considerable portion of the load was due to lineshaft losses and the power company was induced to reduce the minimum of the preliminary contract to 100 kw. with the promise that if at the end of the construction period this was found to be excessive it would be further reduced. Until the hot weather set in this summer, the peak did not exceed 64 kw., but since then it has reached 121 kw. Consequently the original contract will not be changed. It should be noted that the peak is caused by the compressors supplying refrigeration. In the Philadelphia plant, these compressors were steam driven and hence were not included in the original estimate.

Arc Welding Reduces Steel Required in Buildings

ERECTION of two structural steel buildings that will undoubtedly make steel history, has been announced by the Westinghouse Electric & Mfg. Co. The structural steel in both of these buildings will be arc-welded throughout instead of riveted.

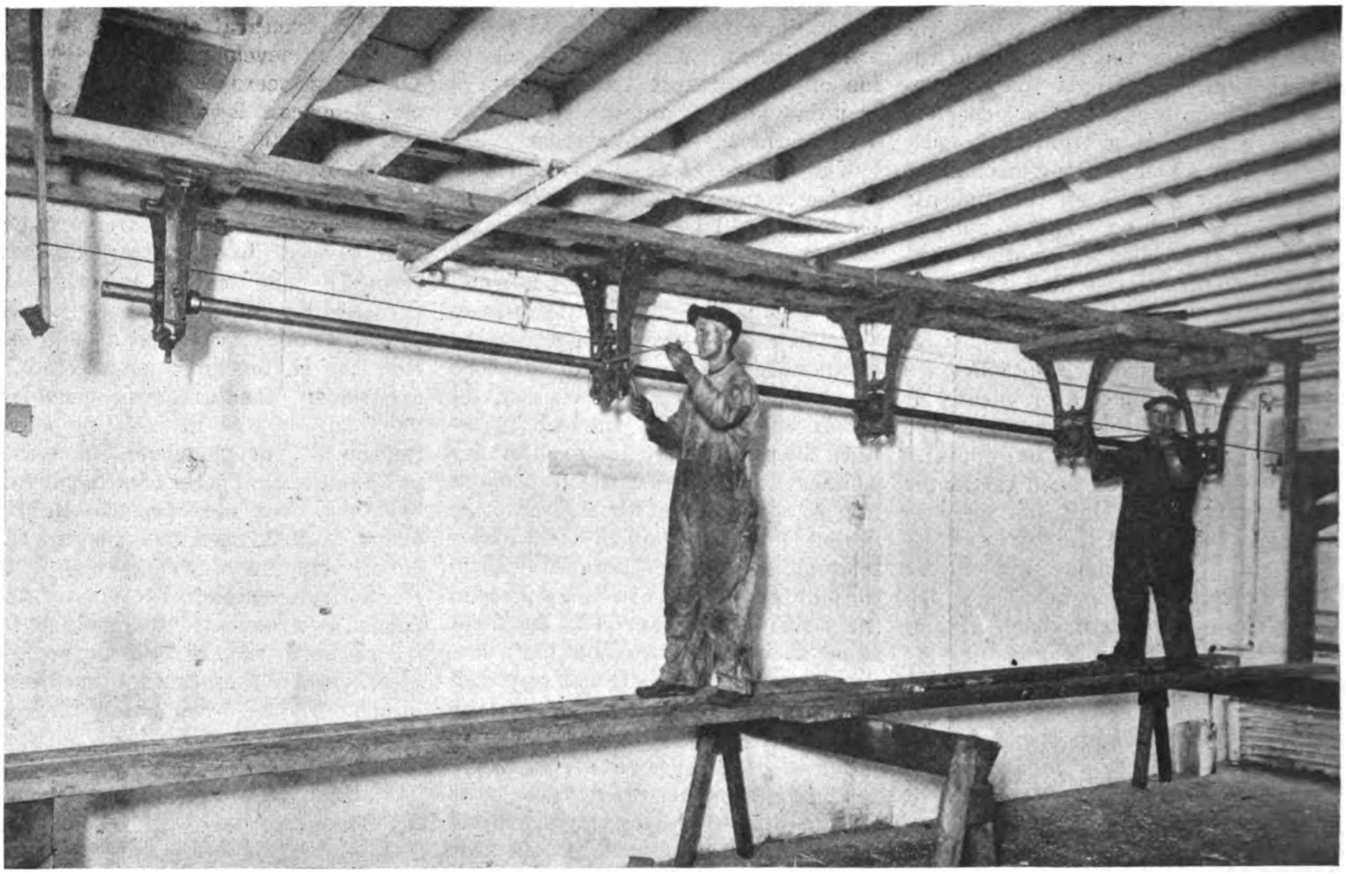
The two proposed structures include a one-story building to be used as an engineering laboratory in the East Pittsburgh Works and a five-story, mill-type building to be used in the manufacture of transformers in the Sharon Works.

The five-story building at Sharon will, when completed, be the largest arc-welded or rivetless building in the world, and is said to be the first application of arc-welding to the building of multiple-storied structures. It will be the first building in the world with all joints and members designed for arc-welding. It is a radical departure from previous practice in that practically none of the members could be joined except by arc-welding. The one-story East Pittsburgh structure is unusual, in that it is being erected partly of scrap roof trusses.

Arc-welding as applied to the erection of structural steel has been in process of development by Westinghouse engineers co-operating with the American Bridge Company for some time, during which tests conducted in the Carnegie Institute laboratories have developed the fact that arc-welded joints are stronger than riveted joints and are, in fact, stronger and more resistive to pressure and stresses than the adjacent beams. It was also found that the saving in steel effected in arc-welded structures was considerable, not only because of the elimination of the thousands of plates and angles now necessary in riveted buildings, but also because lighter beams could be used, thus making the entire structure weigh less. In riveted construction, the size of the beams is frequently determined by the strength required of the riveted joint rather than of the members joined. In the Sharon building, in which approximately 700 tons of steel will be used, there are 100 tons less steel than would be necessary if the structure were to be riveted. This alone means a saving of about 12 per cent in steel cost. A considerable benefit to be derived from arc-welded structures also lies in the elimination of the noisy riveting hammer, whose nerve-wracking noises now herald the erection of all steel structures.

In the steel fabricating mill, the arc-welded members will entail a decided change in the process of assembly. The present system includes the design of thousands of angles and bracing plates, all of which, together with the beams, are laid out and punched, before being delivered to the riveting gangs for assembly. With the new process, the work will be laid out on the floor where the arc-welder will supplant a gang of riveters.

The new process means a return to days of long past in structural steel history, when nearly all of the men in the shop had to have practical knowledge and skill in the fabrication of steel members. It will mean a thorough knowledge of the assembly of steel members from beginning to end. Arc-welding jobs must be laid out on the floor, which will eliminate a number of processes now used, by which the steel members are delivered to the shop workers, already punched and fitted. The assembly process in arc welding will undoubtedly require a higher average type of workman and more technical supervision.



This is the last step in lining up a lineshaft.

The method of taking care of the construction problems incidental to a sloping ceiling, by using hangers of different sizes and blocking as necessary, is described at length in the accompanying article. After the ball bearings were put in the hanger boxes and placed in position in the hangers, the shaft was leveled with a level having a V-base, by adjusting the vertical screws in the four-point adjustable hanger. A line was then stretched parallel to the shaft and fastened to targets (which, in this case, consist of boards nailed to the ceiling joists). The line is fastened to a target at one end and the target at the other end, which is held by a single nail, is then adjusted so that the distance from the line to the shaft is the same at each end before the second target is nailed securely. The final step in aligning is to see that this distance from the line to the shaft is the same at all hangers, and then tighten up the side-adjusting screws. The shaft is then checked over both with the level and with the rule.

Step-by-step operations in

Erecting and Aligning a Lineshaft Drive

By GEORGE TRIMM
Millwright Superintendent, Chicago Pulley & Shafting Co., Chicago, Ill.

PROBLEMS connected with the erection and aligning of a lineshaft vary according to the building construction, as was pointed out in a previous article entitled, "Groundwork Necessary Before Erecting a Lineshaft," which appeared on page 519 in the November, 1925, issue of INDUSTRIAL ENGINEER. This previous article discussed some of the general problems encountered in such work and gave particular attention to the special difficulties incidental to the construction of the building. It covered merely the work necessary in the supporting of the hangers, and did not take into any account the method of installing and aligning the shaft.

The procedure in installing a shaft which is of considerable length is so extensive as to be difficult to explain and show in detail in a single illustration. A recent job, however, presented some very interesting features and problems, and also was small enough so that it can be shown complete in a single view and to permit of a discussion of the various steps involved. A larger job, which involves several lengths of lineshafting would be erected in exactly the same manner and would be a repetition of the steps explained in connection with this installation. Following the discussion of the problems incidental to this installation, other features commonly met in such work, will be considered in a later article.

This installation is an addition to the buffing department of a plant specializing in electroplating and was erected on the top floor of a mill-constructed mill. One of the most difficult features connected with this installation lay in the fact that the room had a sloping ceiling.

The millwrighting consisted of installing one 24-ft. section of 2$\frac{7}{16}$-in. lineshaft, six ball-bearing, loose-pulley countershafts, six buffing wheels and the erection of a platform for supporting the motor, together with the necessary pulleys and belts. The installation of the exhaust pipe and branches, together with the exhaust fan and necessary wiring, will not be covered in this article.

Practically always the first step in any similar millwrighting job is the installation of the lineshaft because all other equipment is aligned from the shaft. A mill-constructed building, as explained in the previous article, is usually the easiest type of

construction for erecting the necessary groundwork, providing the structure is substantial enough to hold the shaft and the groundwork rigidly. In this case the roof structure is very substantial and as the shaft was to be placed close to a wall, its alignment would not be likely to be affected by a snow load on the roof, as might be the case if the lineshaft were placed nearer the center of the joist span.

In erecting the groundwork for the shaft the sloping roof offered two obvious methods of construction. I am a firm believer that the best method of supporting lineshaft hangers in mill-constructed buildings is to attach them to a pair of horizontal stringers extending in the same direction as the shaft. One method of doing this would be to build staging from the ceiling structure and attach the stringers to it. This procedure would have made the stringers practically level and all shaft hangers could have been of the same dimensions. However, this method would have required considerably more structure; also, as the ceiling drop in the length of the shaft is about 12 in., this type of structure would have been somewhat more difficult to brace securely than the type of construction chosen. On the whole, this method would have been more expensive, although a small amount would have been saved in the cost of the hangers in that all hangers would have been of uniform size.

The method of support shown in the illustration on page 398, which consists in attaching the stringers to the joists by means of ⅝-in. by 6-in. lagscrews gives a footing for the hangers which, I believe, is as substantial as the building, in that it is subject only to misalignment which may be due to movement of the joists or ceiling. These footings were made of pieces of 3-in. by 8-in. yellow pine and were lagscrewed directly to the joists. In places where the joists were uneven thin blocks were placed under the stringers so that they lie in practically a straight line, instead of being pulled up or pushed down by tightening up against uneven joists.

The first step, however, was to lay out roughly the location of the various machines to get the approximate location of the countershaft, and from this the position of the pulleys on the shaft, so that no hangers would be placed where they would interfere with the operation of a pulley. Also, it is good practice to place all pulleys, wherever possible, so that they are the width of the belt from a hanger. The reason for this is that if the belts should slip off the pulleys there is less danger of their getting caught if pulleys and hangers are not too close together. For the same reason pulleys should not be too close together.

The diameters of the pulleys determine the distance of the shaft from the wall. In this instance it was necessary to take into consideration the location of a pipe line and the building pilaster which projected about 6 in. from the wall into the room between the third and fourth hangers from one end, as may be seen in the illustration. The pulleys driving the ball-bearing, loose-pulley countershaft are 28 in. in diameter and the main driving pulley is 32 in. in diameter. The required distance was, therefore, the radius of 16 in., plus the thickness of the belt, plus a minimum safe allowance of 3 in. between the pulley and the wall, plus the 6-in. pilaster, which gives a total distance from the wall of approximately 25 or 26 in.

The next step was to measure off on the ceiling this distance of 26 in. from the wall to determine the location of the two ends of the center line of the groundwork. A line stretched between these two points should lie directly above the lineshaft when it is put in. This line, which should be of heavy cord that does not stretch, can be supported from spikes driven into the joists at each end. The distance of the center of the stringers from this line is equal to one-half of the distance between the centers of the slotted bolt holes in the feet of the hangers. In this case hangers of three different dimensions were used. This distance was chosen to fit the feet on the middle-sized hanger.

The stringers were then lined up from this tight line to the center of the stringer or, as it is easier to measure from the edge of the stringer, half of the width of the stringer was subtracted, which gave the distance to the inside edge of the stringer.

The next step was to erect the five hangers, which were spaced about 5 ft. 8 in. apart. Although the standard spacing for shaft hangers is 8 ft. it was considered advisable here to put the hangers closer together because the heavy pull of the motor and buffers, particularly when starting, came from one side of the shaft. The shaft was permitted to extend from each end hanger, particularly at the end nearest the camera where it may be necessary later to add another piece of shafting. To make it unnecessary to do a great deal of blocking or staging beneath the feet of the various hangers on account of the sloping ceiling, hangers of three different drops were used. The first hanger, counting from the end next the

Partial List of Materials and Equipment Used

24 ft. 2 3/16-in. turned lineshaft

1 14/16-in., Chicago, No. 4, four-point adjustable, medium-duty, drop hanger

1 18/20-in., Chicago, No. 4, four-point adjustable, medium-duty, drop hanger

3 22/24-in., Chicago, No. 4, four-point adjustable, medium-duty, drop hangers

6 SKF double-race, industrial-type, medium-duty, self-aligning ball bearings

6 Chicago special hanger boxes for SKF ball bearings

1 32-in. by 8-in. Oneida steel split pulley

6 28-in. by 10-in. Oneida wood split pulley without crown

2 2 3/16-in. collars with set screws

6 Daggett ball-bearing loose pulley countershafts

209 ft. 4-in. Allen, Supertan waterproof, single leather belt

57 ft. 8-in. Alexander double leather belt (17 ft. on exhauster drive)

2 pkgs. No. 5 Clipper belt fasteners

1 20-hp., 800-r.p.m., 230-volt, compound-wound, General Electric, d.c. motor

1 25-hp., 1,150-r.p.m., 230-volt, Western Electric d.c. motor (for exhauster)

1 8-in. by 10-in. Rockwood motor pulley

1 6-in. by 10-in. Rockwood motor pulley (on exhauster drive)

1 American Blower Co. 60-in. exhaust fan

2 Trumbull Type C, two-pole, 100-amp. safety switches

2 Cutler-Hammer motor starters

1 Cyclone separator

12 Galvanized-iron exhaust hoods with 5-in. pipe connection

1 Galvanized-iron main exhaust pipe varying from 8 in. to 26 in. in diameter and 90 ft. long with 20 5-in. inlets (only 12 are now in use)

camera, has a 14/16-in. drop, the second hanger an 18/20-in. drop and the other three hangers have a 22/24-in. drop. These drops took care of the sloping ceiling very well and blocking was required under the feet of the last two hangers only.

The first hanger was then positioned. The bolt holes for this hanger were located and centered up by measuring from the edge of the stringers, although if these had not been so accurately placed it would have been necessary to measure from the line that was already stretched between the stringers to get the center of the bolt slot in the feet.

The overhead line between the stringers was then taken down and stretched on a level with the side-adjusting screws of this first hanger. This was a leveling line and was used to indicate the level of the center of the openings on all hangers. This line was drawn taut and fastened to boards or targets nailed to the joists and extending down from the ceiling. This line was leveled up with a line level, which is a very light spirit level with hooks at the ends for attaching to the line. This line must be level, but it is not necessary to have it absolutely parallel with the shaft, although it is best to have it approximately so.

The amount of blocking necessary under each hanger was determined by measuring up from this line to the stringer. The necessary blocking was cut off and nailed to the stringer before the hole was bored for the ⅝-in. bolt supporting the feet. As the stringers sloped with the ceiling it was necessary to place wedges either between the feet and the blocking or the blocking and the stringers so that the hangers would stand vertical, as determined by a plumb bob. The last hanger required the most blocking and necessitated using 10-in. bolts. This construction, however, is much more substantial, I believe, than would have been the case if the blocking had been placed beneath the stringer.

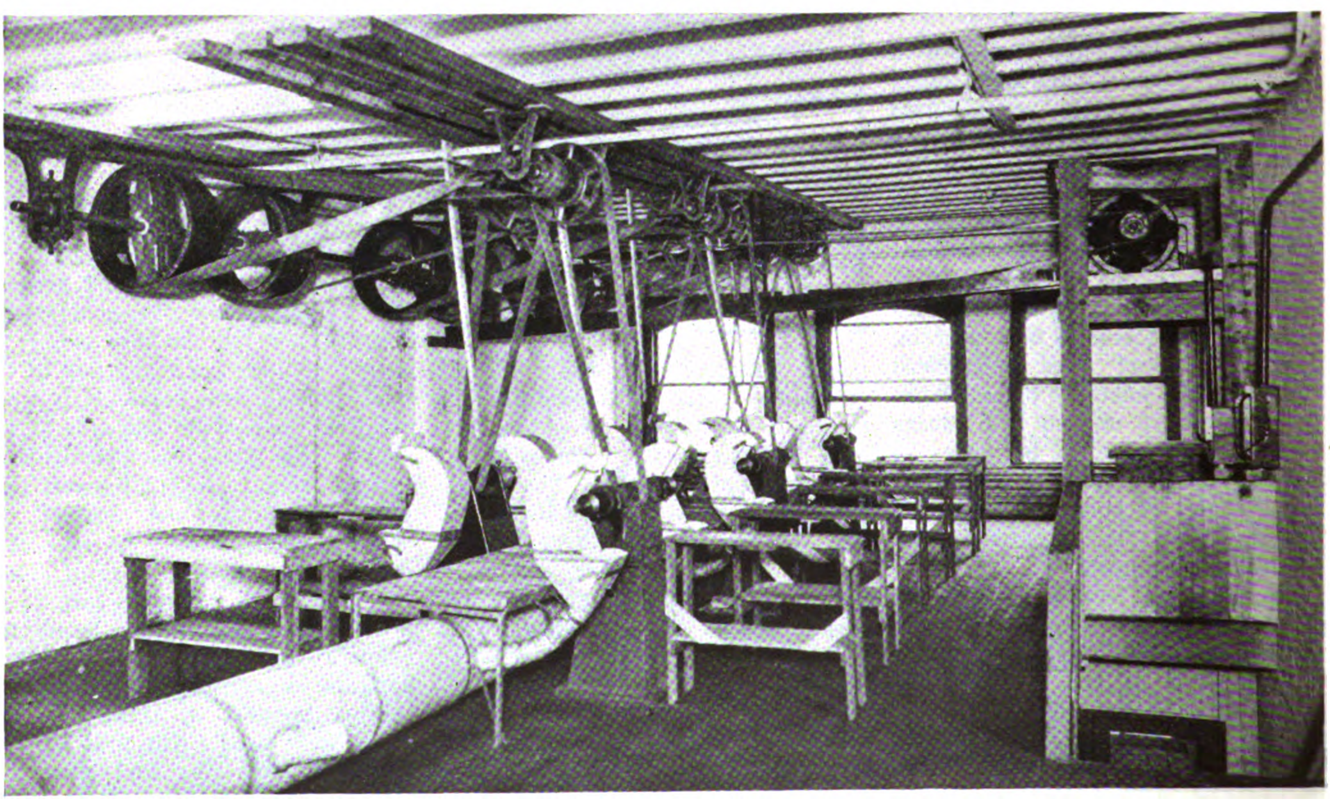
If the pitch of the ceiling had been much greater it would have been necessary to place staging under the stringers. Where the ceiling is level, and the stringers are also level hangers of one size can be used and the construction work would have been much more simple. In such a case, the two end hangers should be erected first and the hanger at one end lowered as necessary until their centers are level with the line. The remaining hangers can then be placed in position with their side-adjusting screws aligned from this line.

After the hangers were in position the next step was to place the lineshaft and bearings. The lineshaft was slipped in from the end hanger. In this operation care must be taken to see that the shaft is not scratched or bent in handling. A little care in the handling of a length of shaft to prevent bending it will save much time, labor and trouble later. This is a point upon which too much emphasis cannot be placed. It is of little use to put a bent shaft into position and expect to force it into alignment by tightening up on the adjusting screws. Also, it is far easier to prevent the shaft from becoming bent than it is to straighten it afterward.

If solid pulleys had been used it would have been necessary to place these on the shaft before erecting and to put the latter in position by opening the drops on the hangers and raising the shaft up from the floor into position, afterward replacing the drops. With solid pulleys also, care must be exercised to see that

This shows the same lineshaft as in the other illustration, but after the entire job was completed.

This section of lineshaft was installed to drive six buffing machines through ball-bearing loose pulleys. The motor platform is constructed of 3-in. by 8-in. yellow pine planks bolted together. The 8-in. leather motor belt is cemented endless. The other belts are 4-in. single leather and are joined by Clipper No. 5 belt laces. The galvanized exhaust pipe is riveted and soldered at the joints. The exhaust fan, which is connected to its motor drive by an 8-in. double leather belt, is located at the other end of the room and the cyclone exhauster is on the roof. This exhaust line is supported by strap and angle irons. A protecting platform is built over it on an angle-iron framework. One section of this framework was removed when this photograph was taken.



the ball bearings are placed in position between the pulleys when they are so located, before installing the pulley; otherwise it must be removed to install them.

After the lineshaft was placed in the hangers, the next step was to file the sharp edge around the circumference of the shaft at each end so that the bearings would slip on more easily. SKF medium-duty, industrial-type, double-race, self-adjusting bearings were fitted into a ball-type hanger box made especially for these bearings and the medium-duty, four-point adjustable, Chicago No. 4, cast-iron drop hangers. The hanger box shell and the bearings were slipped over the ends of the shaft separately. When the shell and ball races were approximately at the location of the hanger, they were fitted together, packed with grease, tightened up, and the cover screwed on. The collars, which fit at the ends of the shaft inside the hangers, should not be forgotten and so make it necessary to remove the bearings to insert them.

The boxes were then positioned in the hanger yokes and tightened up by means of the adjusting screws. The final tightening process should continue all the way along the shaft, instead of working only at one hanger until it is completely finished. When these adjusting screws began to tighten, the shaft was checked by means of a level and positioned by shifting the vertical adjusting screws.

The shaft was then ready for side adjustment and the line was repositioned. Where the line is in a convenient location and practically level with the shaft, it is merely necessary to shift it at one end or the other until the distance from the line to the shaft is exactly the same at each end. The line is in this position in the illustration shown on page 398. It is best for one individual to make the measurements at both ends, because two people can easily read the rule a fraction of an inch differently. The other millwrights can then take their readings and work independently at other bearings.

The side adjustments were made by tightening or loosening the side screws on the hangers until the measurements from the line to the shaft were exactly the same at all bearings. The shaft was again checked for level and all adjusting screws were gone over again for a final tightening. When all screws have been tightened, a final check should again be made with the level and the rule. By this time a shaft fitted with ball bearings should turn freely and easily by hand. If it does not, it is probably bent.

While the scaffolding was in position, the pulleys were next placed on the shaft in approximate position but not tightened up, so that they could be shifted easily. Oneida wood split pulleys, 28 in. by 10 in., without crowns because of the shifting belt, were used on the lineshaft to drive the buffer countershafts. The groundwork for the countershafts was then placed in position and lined up by measuring over from the stringers which support the lineshaft. This groundwork consisted of pieces of 3-in. by 6-in. by 16-ft. yellow pine. One end of each Daggett ball-bearing, loose-pulley countershaft was blocked up on account of the pitch of the ceiling so that its shaft is level. These were lined up by measuring with a steel tape from the lineshaft to each end of the countershaft.

The six buffing wheels are placed in two rows, back-to-back, so that three of the countershafts are driven by crossed belts. The 28-in. by 10-in. pulleys on the lineshaft drive the countershafts with 4-in. belts on 8-in. by 5-in. tight pulleys. The main drive pulleys on the countershafts are 16-in. by 5-in. and drive down to the pulleys on the buffers through 4-in. belts. The lineshaft is operated at about 200 r.p.m. and the buffing wheels at about 2,300 r.p.m.

Three of the buffing wheels have Timken roller bearings and the other three, ball bearings. The buffing machines are fastened to the floor by lagscrews which extend through the floor and into the joists. To be sure that these lagscrews would screw into the joist properly, it was necessary to go to the floor below and measure the center distances of the various joists from the end of the building. If it had been necessary to place these buffers where they could not have been lagged to these joists, they could have been bolted to a short stringer placed crosswise against the ceiling between joists on the floor below. This would have provided a substantial mounting. The shafts of these buffers were aligned by eye and with each other as it is not essential that they be absolutely parallel with the lineshaft.

The exhaust hoods and main exhaust pipe were placed between the two rows of buffers, and a platform resting on angle-iron supports was built over them for protection, as may be seen from the illustration on page 400.

The method of constructing the platform for supporting the motor is also interesting. This is a 25-hp., 230-volt, 800-r.p.m., Type RC, compound - wound, General Electric direct-current motor. This installation is located in the older downtown section of Chicago where direct current is supplied by the Commonwealth Edison Company, from which power is purchased. The motor is controlled through a two-pole, 100-amp. Type C Trumbull safety switch and a Cutler-Hammer starter. The 8-in. by 10-in. Rockwood pulley on the motor is connected by an 8-in. Alexander, first - quality, double leather belt to an Oneida 32-in. by 8-in. steel split pulley on the lineshaft, on approximately 16-ft. centers.

The motor platform was also made of 3-in. by 8-in. planks, the same as was used for the stringers. The ends of the planks rest on similar stringers laid on the floor. The tops of the vertical support were bolted to the ceiling joists. As an additional support to resist the pull of the motor belt another 3-in. by 8-in. stringer was fastened to the brick wall by expansion shells and the platform bolted to this. In addition to the uprights which are placed on each side of the motor platform an additional pair of short uprights support the platform in the center.

The base of this platform measures 6 ft. by 4 ft. and is 7 ft. above the floor. This gives ample headroom under the belt. The workers are also protected by a sheet-metal guard reinforced with angle iron, which extends from the platform over to the lineshaft pulley. A sheet-steel canopy extends across this platform above the motor for fire protection. Also, the platform is covered with galvanized iron which is bent up at the edge to form a drip pan entirely around the motor.

The 4-in. waterproof single belts from the lineshaft to the loose pulleys and from the tight pulley down to the buffers were joined by No. 5 Clipper belt lacing. These belts were measured by running a steel tape around the two pulleys and cut with an allowance of ⅛ in. per foot in length to give the proper tension and allow for stretch. The motor belt was connected endless, after it was installed, by using belt clamps.

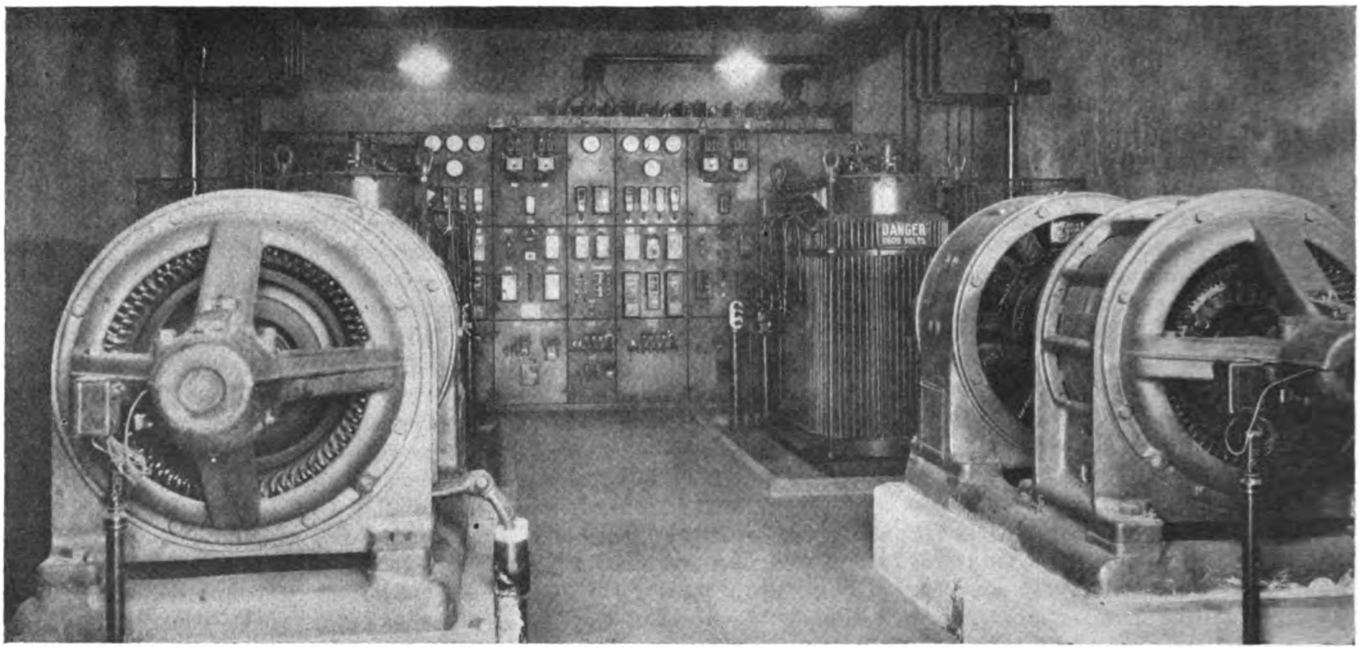


Fig. 1—This automatic switching equipment is located in a small steel mill substation.
It controls two 100-kw., 275-volt, squirrel-cage motor-generator sets, which supply power to the plant office building of the McKinney Steel Co. at Cleveland, Ohio.

Using Automatic Switching Equipment

in industrial plants to reduce substation operating costs and secure better protection against breakdowns and damage to the substation equipment

By F. E. JAQUAY
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During the past year there has been a marked advance in the application of automatic switching equipment in all lines of power consumption. Among machine equipments there was a noticeable trend toward the use of single units instead of multiple-unit stations, thus indicating a growing appreciation of the application principles of automatic equipment. However, several double-unit stations, with the second machine arranged to start following an overload on the first, were placed in operation.

Automatically-operated synchronous converters and motor-generator sets are helping to solve the problems of power supply at the mines. An installation typical of those in mine service is shown in Fig. 2. The principal devices for the control of this type of converter are the main oil circuit breaker, starting and running contactors, a small, field-flashing motor-generator set, a brush-operating mechanism and various small contactors and relays for directing the several operations once the master element is closed, giving the starting indication.

Since there are, in most instances, workmen present in the vicinity of mining substations, automatic starting by means of a time clock is often omitted. In such cases the initial impulse is given by actuating the master element either locally or from a remote point. The station shown is started by an attendant actuating the master element locally. The sequence thereafter is entirely automatic, the first action to take place being the closing of the master contactor and then the starting contactor, which connects the converter to starting taps on the power transformer. The converter field is flashed following the indication of synchronous speed by the synchronous speed device. Correct polarity being established, the machine is made self-excited and then connected to full running voltage. The brushes are then lowered on the commutator and the machine is ready to carry load. The feeder is connected to the machine automatically and when the machine is once placed in service it will function without further attention.

The usual protective devices are included in this equipment for the machine and feeder and function in case of reverse power, overheated bearings, overheated machine windings, incomplete starting, a.c. and d.c. overcurrent.

The McKinney Steel Company is using automatic equipment extensively in coal mining and steel mill operations. One of their substations located at Wolf Pit, Ky., contains a 200-kw., 250/275-volt, synchronous motor-generator set and two stub multiple d.c. reclosing feeders. An interior view of the station is shown in Fig. 3.

Some special features used in the control equipment for this station are of interest. The usual compensator tap starting method is employed, the motor in each case being connected to the 4,000-volt, incoming line through disconnecting switches and choke coils. Each of the remote and local master elements used for starting, functions through a relay which interposes a time delay before the master contactor closes. A line contactor is provided in the generator circuit to connect the machine to the 250/275-volt, d.c. bus to which the two stub-multiple feeders are connected.

On this equipment the relay which

usually trips the line breaker in case of an incomplete starting sequence is connected to energize an auxiliary hand react relay which in turn interrupts the master control circuit. A complete shutting down operation, therefore, takes place on starting failure the same as though the main a.c. line were opened directly.

Bearing in mind the features just described the starting operation consists only of closing either one of the master elements. The protective devices being in their correct positions, the master control circuit is completed after a time delay. The unit then starts by the closing of an oil-immersed contactor which connects the motor to the line through a compensator. As soon as sufficient speed is obtained, the running contactor closes and the starting contactor drops out, leaving the motor connected to full a.c. voltage. When the generator voltage is slightly above the bus voltage, the main line contactor connects the generator to the bus. Each of the feeders is then connected to the bus automatically.

The Hillman Coal and Coke Company is now installing automatic equipment at Jerome, Pa., to control a 275-volt, 300-kw., synchronous motor-generator set to operate in combination with a stub-multiple feeder. This equipment is practically the same as that previously described for the McKinney Steel Company except that it is of greater capacity. Starting is accomplished directly and without time delay by closing the master element. In case of an incomplete starting sequence the main oil circuit breaker opens to cause a shutdown. This breaker must be closed manually before a new start can be made.

The steel industry is likewise turning to automatic switching equipment for the solution of certain operating problems. An interesting steel mill equipment was purchased during the past year by the Youngstown Sheet and Tube Company. It consists of two separate, automatic switching equipments for two, 275-volt, 1,000-kw., motor-generator sets, together with the latest design of feeders and type MC-2 breakers.

In order that the functioning of this equipment may be better understood, a description of its operation will be given. The principal steps in starting a unit and connecting it to the d.c. bus are as follows:

(1) If three-phase voltage of normal value is indicated and all protective devices are reset, the unit may be started by the attendant operating a pull button switch at a remote point. Starting can also be accomplished locally if desired. From this point the sequence is entirely automatic.

(2) The machine starts and comes up to synchronous speed by the application through reactors of low voltage to the synchronous motor. At the same time the voltage regulator motor-generator set starts and the negative main line breaker is closed.

(3) A few seconds after synchronous speed is reached, the voltage of the generator having built up to approximately 65 per cent of normal and the polarity being correct, field is applied to the synchronous motor.

(4) When the motor field is approximately one-half its normal value, the reactors are shunted and the motor connected directly to full voltage.

(5) As soon as the voltage regulating equipment has adjusted the generator voltage so that it is approximately equal to that of the bus, the positive d.c. line breaker is closed and the generator is connected to the bus.

(6) The machine then carries load until it is shut down manually, by the operation of some protective device, or is temporarily disconnected from the d.c. bus due to abnormal line conditions.

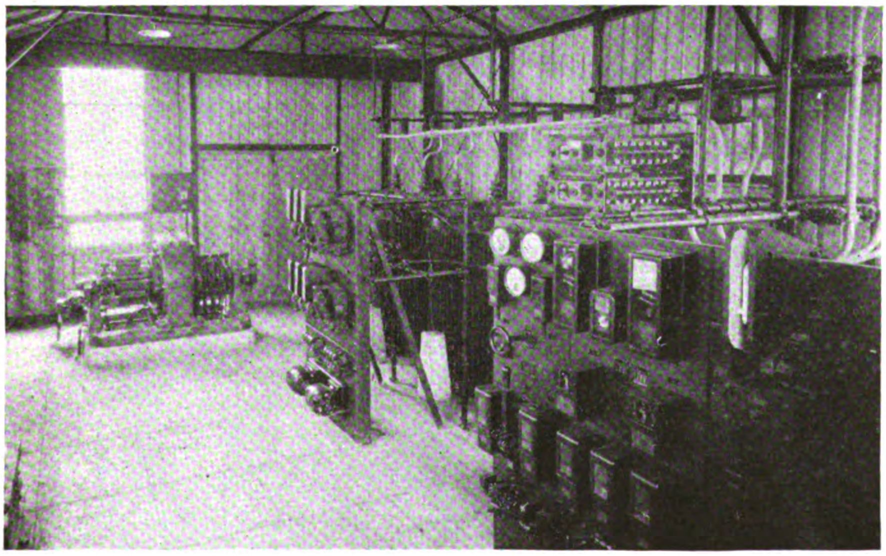
The Dennison Manufacturing Company, Framingham, Mass., has recently put in an installation which consists of two 250-volt, synchronous converters of 330-kw. capacity, operating on purchased energy of 13,200 volts stepped down through power transformers. The automatic control panels are mounted under a gallery with the machines directly above. The starting and running contactors are mounted on a separate panel adjacent to the balance of the control devices. Figs. 5 and 6 show the general layout of this installation. Each machine is provided with a brush-raising mechanism and arranged to start by closing the d.c. line breaker. When the machines are ready to carry load they function in parallel with steam-engine-driven units, a feature which particularly emphasizes the flexibility of automatic control. Since other equipment in the station requires an attendant, straight automatic starting is not used, although it was provided for.

Protection is arranged for such irregularities in operation as a.c. undervoltage, overheated machine windings, field failure, wrong brush position, underspeed, a.c. or d.c. overload, overheated bearings, overspeed, d.c. reverse power, and single-phase starting and running. An interlocking circuit between the two units prevents starting both at the same time.

The procedure in starting a converter is as follows: With the disconnecting switches and oil circuit breaker between the high-tension supply and the power transformer closed, control power is made available for starting. The attendant then closes the hand-operated, single-

Fig. 2—Here is an automatically-controlled, rotary converter substation in mine service.

The rotary converter controlled by this automatic switching equipment is rated at 300 kw., 275 volts, direct current.



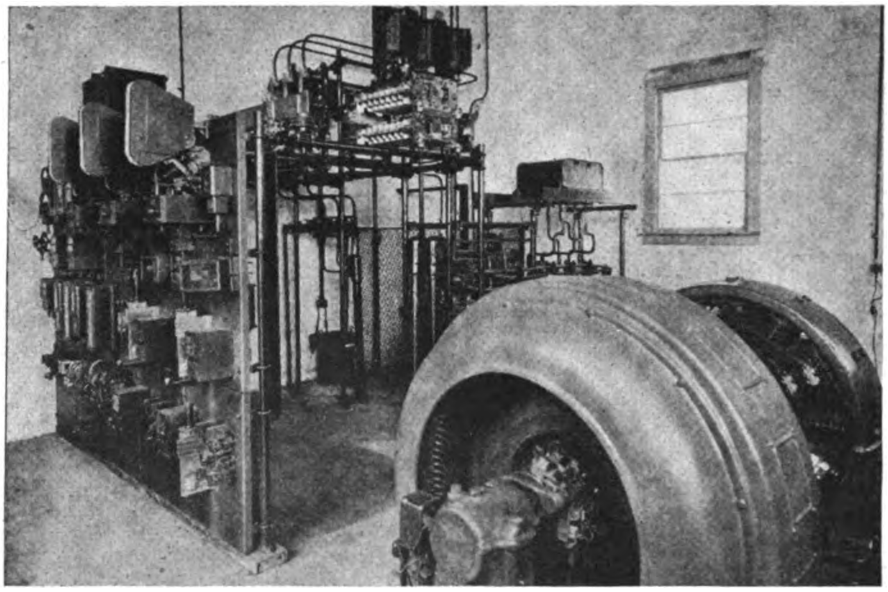


Fig. 3—This automatic substation supplies the power for a coal mine.

The automatic switchboard controls a 200-kw., 250/275-volt, synchronous, motor-generator set at the Wolf Pit coal mines of the McKinney Steel Co. In addition it controls two stub-multiple feeders. The two panels shown at the right end of the switchboard perform this service.

pole circuit breaker in the positive side of the converter, thereby energizing the undervoltage relay. This device, in combination with another relay, completes the master control circuit.

From this point the starting sequence proceeds until the converter is connected to full a.c. voltage through the operation of the starting and running contactors, the field having been flashed in the meantime from a small motor-generator set. The brushes are lowered on the commutator and the attendant, after checking the bus and machine voltages, proceeds to connect the converter to the 250-volt station bus. A main line contactor, however, will hold the machine off the bus until the converter voltage is slightly above that of the bus. The closing of the main contactor still leaves resistors in series with the converter to give overload protection. Normal load conditions being present, these resistors are each shunted in turn and the machine then takes its share of the load.

If, at any time during operation, an overload condition arises, d.c. overload relays cut the load-limiting resistors into the circuit. Thermal relays mounted above the resistors will operate to cause a shutdown if the overload is carried too long. Since there is an operator in the station, a gong has been provided to warn him of an overloaded condition on the machine. Hence, a shifting of the load may be accomplished on an overload indication before a shutdown takes place.

To shut down manually the operator simply trips the single-pole circuit breaker. This device, by means of an auxiliary switch, interrupts the master control circuit and the equipment assumes the "off" position.

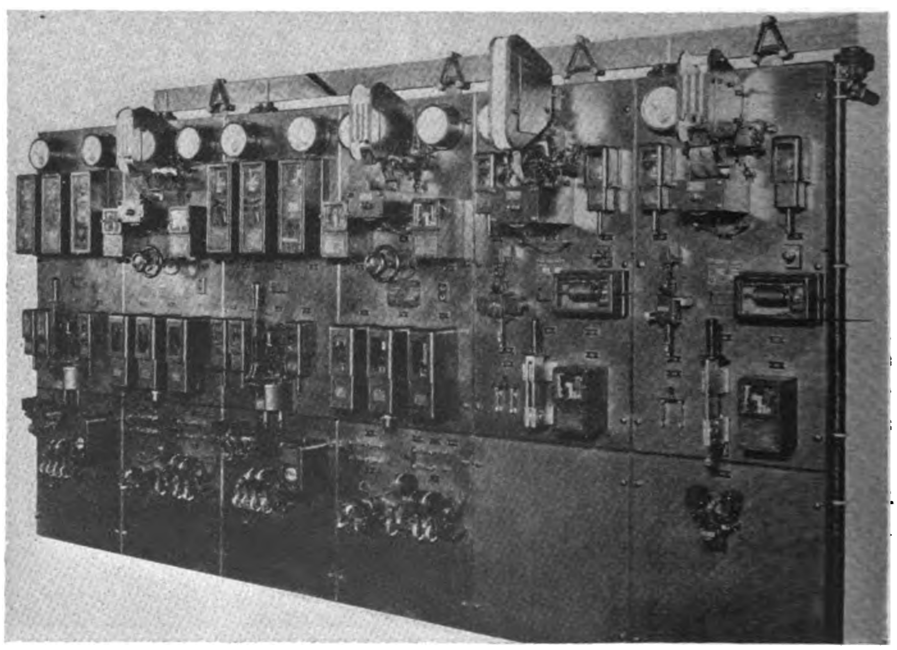
An interesting industrial installation, which has recently been completed, is in the mill of the McKinney Steel Company, Cleveland, Ohio. The power supply for the mill has a frequency of 25 cycles and hence is not suitable for office and drafting room illumination. It was, therefore, decided to install in the basement of the office building two 100-kw. induction motor-generator sets with automatic control. A view of the complete installation is shown in Fig. 1.

Relatively slow speed sets are used so as to minimize the noise, characteristic of higher-speed machines. The control for these sets provides for continuous running of one set and starting of the other on load demand. Counter-e.m.f. regulating equipment is provided to hold the direct-current voltage within very close limits and the usual protective features are also provided. A thermal relay is employed in the neutral lead of each three-wire generator as a protection against overheating of the neutral copper. Functioning of this device causes a shutdown by interrupting the master control circuit. A throw-over switch determines which machine shall be the leading unit. As a special protection to guard against failure of energy for the lighting circuit the second unit is arranged to start in case the first one fails.

Incoming power is supplied to two buses, one of 110 volts and one of 220 volts, from 6,600-volt power transformers. Starting of the sets is, therefore, accomplished directly from the buses by means of the usual starting and running contactors energized at a remote point.

Fig. 4—Automatic switchboard in use by Pennsylvania Coal and Coke Corp. at Mills, Pa.

This equipment controls two 150-kw., motor-generator sets. The first two panels from the left control one motor-generator set while the third and fourth panels control the second. The fifth and sixth panels are stub-multiple, direct-current, feeder panels equipped with reclosing circuit breakers. These panels are rated at 1,640 amp. and 900 amp. respectively.



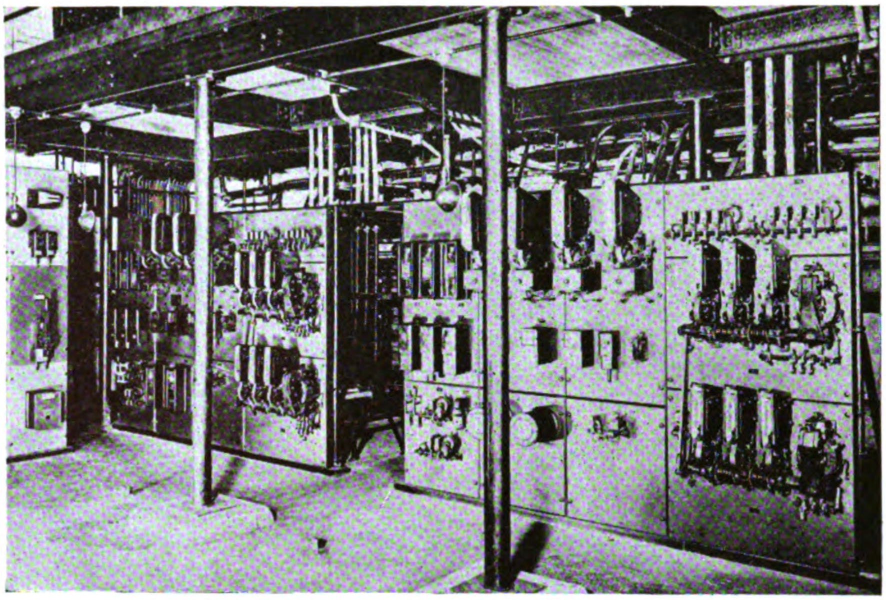


Fig. 5—Flexibility is a distinguishing characteristic of automatic control.

This automatic switching equipment controls two 330-kw. rotary converters and operates them in parallel with steam-engine-driven, direct-current generators. Directly over this switchboard is a balcony which carries the rotary converters shown in Fig. 6. This equipment is in the Framingham (Mass.) plant of the Dennison Manufacturing Co.

With one unit in service and an increase in load of sufficient amount to operate the master element of the second unit, this machine will start and carry its share of the load.

This installation has proved to be a very satisfactory and economical means of supplying direct current to an isolated office building and will no doubt lead to similar installations.

Automatic a.c. reclosing feeders, which have been popular for some time with operating companies, are finding wide application in the industrial field. The rugged construction of these equipments and their dependability have in a large measure contributed to their popularity.

Among the more recent developments in automatic control has been its application to synchronous condensers. Of particular interest in this connection is an installation of equipment to control a unit of 7,500 kva. for the New England Power Company, at Worcester, Mass. The American Steel and Wire Company, one of the larger customers of the New England Power Company, found it necessary to increase materially its supply of electrical energy. As the character of the load made it necessary to compensate for lagging power factor, the power company decided to add another unit to its already existing 40,000 kva. in synchronous condenser equipment. In order to eliminate the necessity for attendants an automatically-operated synchronous condenser rated at 7,500 kva., 13,800 volts was decided upon.

The automatic switching equipment employs a time clock and voltage relay so that if the voltage between the hours of 7 a.m. and 6 p.m. falls below 13,200 the condenser automatically starts up and boosts the potential to about 13,800 volts. It will maintain this voltage within the capacity of the machine until such time as the system voltage rises to a point when a shutdown occurs automatically due to light load. Use is made of the new type alternating-current voltage regulator which has no direct-current coil and hence gives satisfactory control even when the direct-current voltage is at a very low value. This machine is protected against bearing trouble, low voltage, loss of load, single-phase operation, overcurrent, loss of field excitation, and current unbalance.

Severe winter operating conditions had to be provided for in the station design, as the machine does not run continuously. The ventilating duct leading the air away from the condenser is fitted with a butterfly valve so that when the machine stops the warm air is prevented from escaping to the outside. As a further help toward eliminating cold weather difficulties small heating elements were installed in the main bearing oil wells and so connected that they are energized when the machine is shut down.

In conclusion it may be said that in 1914 there was one 300-kw. automatic station in service. In 1925 the number had increased until there were more than 800 automatic stations with a total of over 700,000 kw. in rotating apparatus in successful operation. The installation of these stations is proceeding at an increasingly rapid rate since they have now become an integral part of the electrical engineering art.

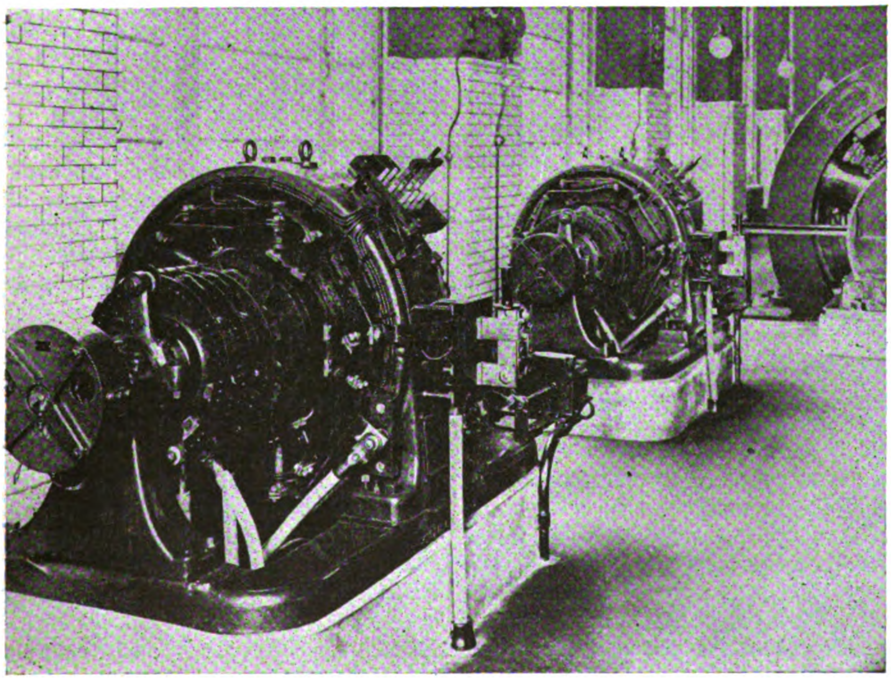
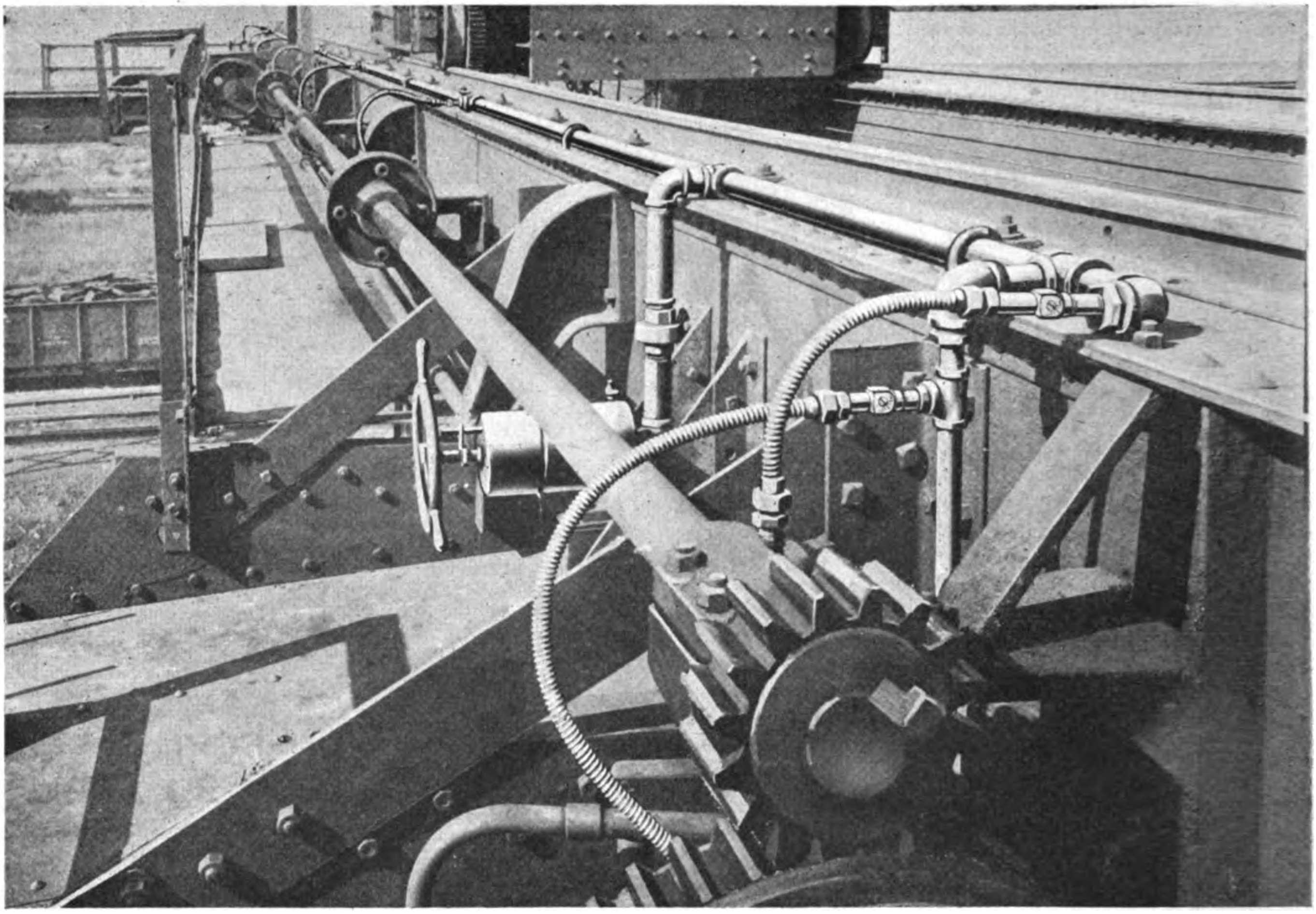


Fig. 6—These rotaries operate in parallel with engine-driven generators and are regulated by automatic control.

The automatic switching equipment controlling them is located directly under the sets and is shown in Fig. 5. The converters are each rated at 330 kw. and deliver 250 volts.



Pressure lubricating equipment for crane bridge bearings.

Grease is applied under pressure to all bearings simultaneously by screwing up the handwheel of the Keystone compression unit in the foreground. Similar equipment for lubricating the trolley bearings is shown in another illustration.

Problems in the

Lubrication of Hoists and Traveling Cranes

including troubles caused by the service conditions, with a discussion of the types of bearings and lubricating devices that may be used to overcome them

By Frank E. Gooding

Associate Editor, Industrial Engineer

LUBRICATION* of material-handling equipment offers, in many ways, greater opportunities for neglect than most other machines which are used in production. Much of this equipment is located in out-of-the-way corners or in places difficult of access, and often it is used only intermittently. Such conditions tend to make for divided responsibility or failure to provide necessary lubrication and inspection.

*Other articles in this series on lubrication, which have appeared in previous issues of INDUSTRIAL ENGINEER are: "Using Oils and Greases for Industrial Lubrication," December, 1925, "Specifications for Oil and Grease Lubricants," March, 1926, "Equipment for Applying Lubricants," May, 1926, and "Lubricating Motor Bearings," July, 1926.

The effects of use are cumulative. Also, when the equipment is idle for comparatively long periods, the lubricant is more likely to accumulate dust in the bearings, because where bearings are operating, the action of the oil, if the bearings are properly designed and the lubricant supplied as indicated by the manufacturer, tends to keep the lubricant in motion, so that it gradually works foreign matter away from the bearing surfaces. Some bearings are designed primarily to force or wash foreign matter out with the flow of the lubricant. This is, of course, impossible when the bearing stands idle. Also, some lubricants tend to gum or harden, particularly when exposed as a thin film, such as covers the bearings. Other lubricants are so thin as to run off and leave the bearing surfaces unprotected, practically as soon as motion stops. Needless to say, a lubricant which is too thin, that is, one without sufficient body, should not be used.

The necessity for the proper application of the correct lubricant applies to practically every type of equipment; in this way the lubrication of material-handling equipment does not differ very much from other bearing problems. However, special provision must be made to anticipate neglect as much as possible, and to handle the problems created by the dust in which much of such equipment operates.

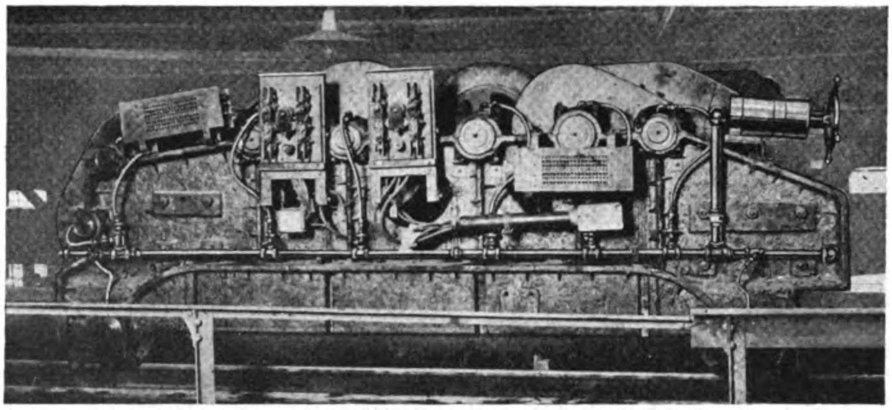
This article will discuss some of the more common methods and considerations involved in the lubrication of material-handling equipment. Particular attention will be given to overhead cranes and hoists. The lubrication of trucks and tractors presents special problems which are

covered by the recommendations of the manufacturer and will not be discussed here.

The electric traveling crane is often the most expensive and sometimes the most important piece of equipment in an industrial plant. Interruption of its service in some industries, such as foundry work, will often tie up a large share if not all of the plant. Due to its large size and the fact that the crane is placed overhead where it is difficult of access, lubrication of the crane bearings is often neglected. The bearings such as in the bridge trucks are located a considerable distance apart and are hard to reach; often, as a result, they do not get the necessary attention. For this reason crane manufacturers usually design the bearings and the method of lubrication so that there will be no serious results even though lubrication is neglected occasionally.

Both the manufacturers and users of cranes are studying the problems of lubrication and bearings very seriously. In the article entitled, "Anti-Friction Bearings on Steel Mill Motors," on page 260 of the June, 1926, issue of INDUSTRIAL ENGINEER, a description is given of an installation of roller bearings applied to 32 traveling cranes on not only the motors, but on all of the bearings.

Also, on page 254 of that same issue, mention is made of the recent installation of 20 cranes which are likewise completely equipped with roller bearings. In these cranes Rollway bearings are used for the motors, Hyatt bearings support the lineshaft, and Timken bearings are used on the axles and end trucks. In many other instances partial installations of anti-friction bearings have been made on cranes. One of the big advantages of using these



Here the trolley of a crane is fitted for pressure lubrication.

The Keystone compression unit is located at the right and ¼-in. lead pipes extend from the 1½-in. header pipe, to each bearing. This unit covers the lubrication of all bearings on the trolley. A separate unit is required for the bridge, as shown in the headpiece at the beginning of this article.

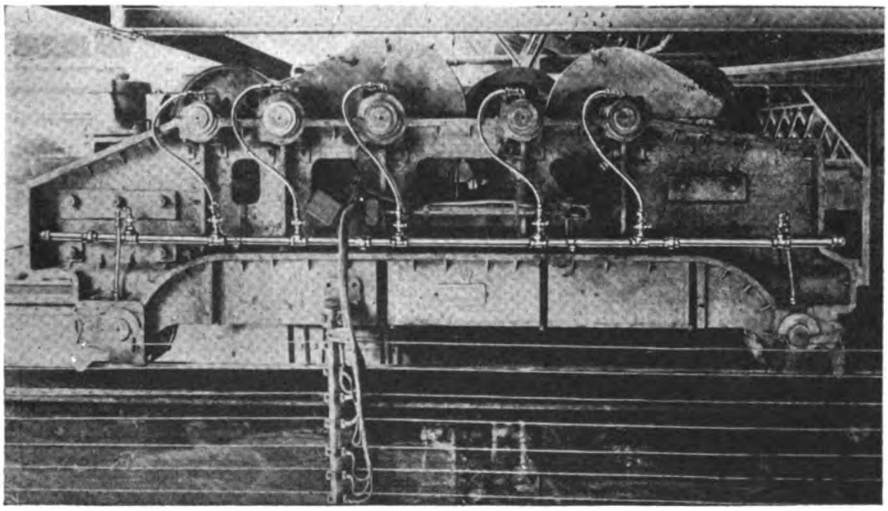
bearings is that they require lubrication only a few times a year at most.

It is expected that the use of anti-friction bearings will do much toward overcoming the difficulties incidental to the operation of cranes in steel mills where they are subject to dust hazards and other severe operating conditions, particularly as continuous operation is of supreme importance in this industry.

A type of bearing commonly used on the end trucks and also on the trolley trucks of cranes is the M. C. B. (Master Car Builders) bearing which usually consists of a bronze or similar bearing metal shell with an oil reservoir, packed with waste.

This is the opposite side of the crane trolley shown above.

A header pipe line carries the grease from the compressor around to the bearings on this side of the trolley. Pressure is exerted on all bearings simultaneously. Where a large number of bearings are served from one compression unit, a two-way or three-way valve is placed in the line so that pressure is applied to only a portion of the bearings at a time.

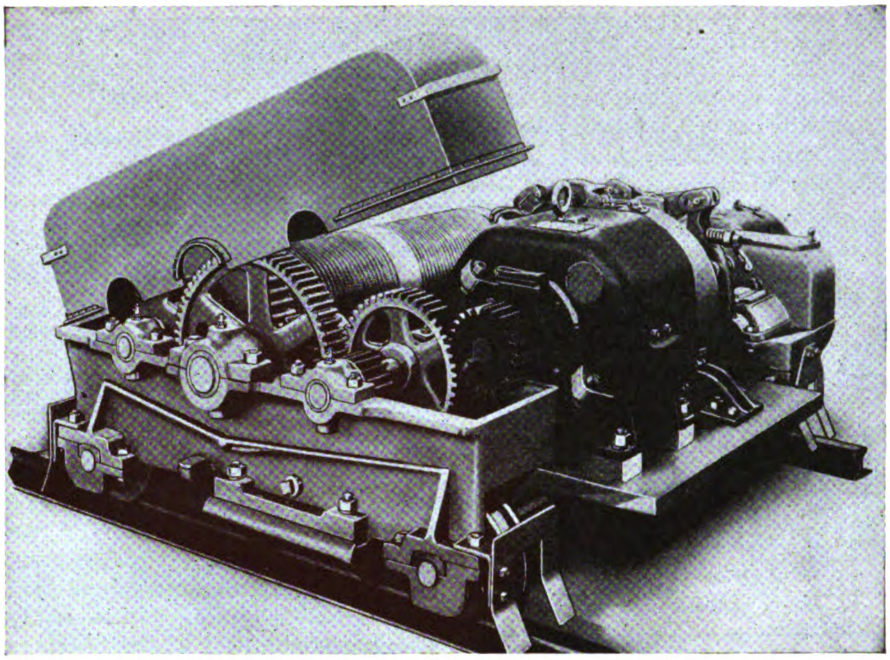


Such bearings require the addition of lubricant weekly. Also, it is advisable to repack with clean, new wool waste approximately every two months. Wool waste does not pack too tightly, it seems to hold and feed the oil better and is not so easily affected by the heat of the bearings as is ordinary cotton waste. A heavy grade of lubricating oil, similar to engine oil, is used in M.C.B. bearings.

Frequently, grease cup lubrication is used on some of the crane bearings, particularly on the bridge drive shaft, and on some of the trolley bearings. When attended properly these give satisfactory service. It is somewhat difficult, however, to fill these grease cups at the crane without getting some dirt mixed in with the grease, particularly where the atmosphere is heavily dust-laden. Some operating engineers overcome this difficulty by having spare grease cups, which are filled at the stockroom. The oiler then merely removes the empty grease cup and replaces it with a filled one. Care must be exercised, however, to see that these are screwed in properly so that they do not loosen and fall out, due to vibration of the crane.

Many operators, however, prefer the use of the Alemite or Zerk, pressure systems of grease lubrication in preference to a grease cup, in that these force the lubricant into the bearing under considerably greater pressure than can be obtained by screwing down on a grease cup. Also, there is less likelihood of forcing dirt into the bearing along with the lubricant, as would be the case where the grease cups were filled in the plant. In addition, all of the new grease is forced in under high pressure, and the old, dirty grease is forced out of the ends of the bearings, carrying with it any foreign matter. The Dot system supplies oil under pressure to the bearings in a similar manner.

With the Alemite or Zerk systems, the lubricant is forced, by a so-called



Lubrication features of a Whiting crane bridge trolley.

The truck wheel bearings are of the M.C.B. type and are packed with wool waste. The gears operate in an oil bath. Other bearings have Alemite fittings for pressure lubrication.

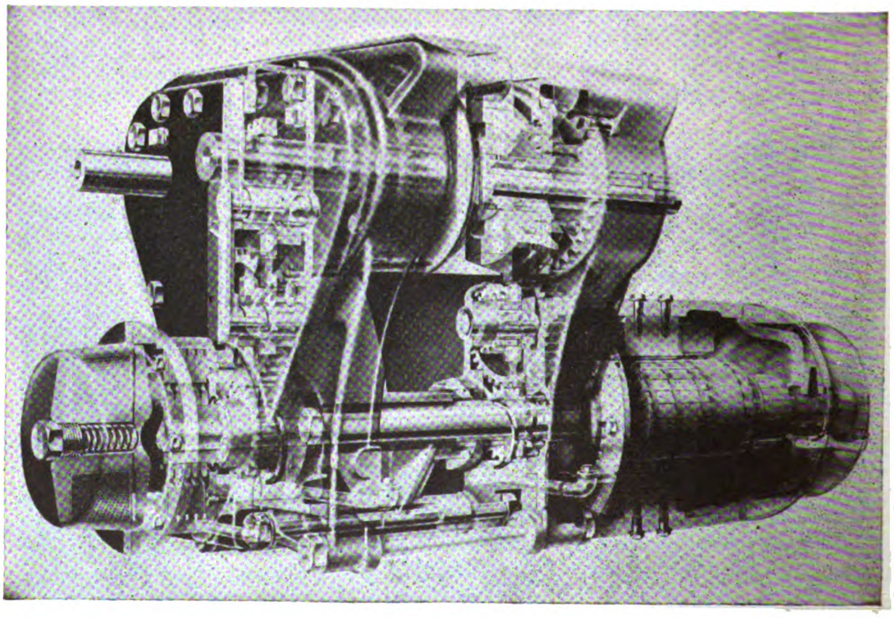
gun, into the bearings through a fitting which is screwed into the oil hole or grease cup opening in the bearing. This fitting is closed by a special ball and spring which is forced open by the passage of the lubricant as it is applied under pressure. The operation of these methods of applying lubricants was described in the article, "Equipment Used for Applying Lubricants," in the May, 1926, issue of INDUSTRIAL ENGINEER. A crane which is in operation approximately 10 hr. a day should have all bearings gone over with a portable pressure gun at least once daily.

Still another method of lubricating electric cranes, which is designed both to supply the lubricant to the bearings under pressure without the possibility of missing a bearing, and also to eliminate the accident hazard which results from the necessity of attending each individual bearing, is known as the Keystone system of lubrication. This was also described in the May, 1926, article. With the Keystone system the grease is piped from a central pressure gun or compression unit to each of the bearings. The application of pressure by screwing up a plunger on this unit lubricates all bearings simultaneously. The advantages claimed are that this is not only a safe method, as there is practically no hazard to the workman, but also no bearings are overlooked, and all the bearings are lubricated very quickly.

Where cranes are so equipped, the Keystone lubricators are of the manual, intermittent-operation type. One lubricator is used for the crane bridge and another for the trolley. Some ore bridges have been equipped with Keystone converter cups r accumulators which are connected in so as to give a continuous flow of grease under pressure to the bearing. The lubricator is mounted in a convenient location, usually at one end, and is connected to the header line which extends along the bridge. Branch feed lines are connected with the header to each bearing and a pressure reduction valve is placed at or adjacent to each bearing. After the pipe lines are filled with lubricant and the valves adjusted, the pressure is applied by turning the hand wheel, which forces grease into all bearings simultaneously. A special grease gage and pressure tell-tale, indicate the existence of pressure and the flow of grease at the various bearings. An installation on the bridge of a yard crane is shown in an accompanying illustration.

This phantom view shows the lubrication system of a hoist trolley.

This illustration is of one type of trolley for a Shepard Electric Crane & Hoist Company hoist. The axle and motor bearings are ring-oiled. Gears, where possible, are lubricated by the splash system, and each oil reservoir is provided with a means for indicating the oil level.



Crane bearings, particularly those which are installed in foundries and around blast furnaces, are subjected to very dirty and dusty conditions. Abrasive material shortens the bearing life, and under such conditions it is necessary to use a lubricant of sufficient body to seal the ends of the bearings against infiltration of dirt.

On some installations grease has been forced a distance of 200 ft. from the lubricator to the farthest bearing, with branches to the various bearings along the line. On all connections which are to be made to a moving bearing and when subject to extreme vibrations a grease-proof rubber hose is employed; otherwise pipe is used.

At the Lynn (Mass.) plant of the General Electric Company, a 5-ton and a 10-ton Whiting crane are equipped with the Keystone lubricating system. The first crane was equipped by the user; the second crane was equipped when manufactured. One compression unit is mounted on the bridge of the crane

(Please turn to page 420)

THIS is the third article of a series on power factor. In the first article, which appeared in the July issue, the nature, causes and effects of low power factor were discussed. The second article, in the August issue, dealt with methods of raising low power factor without the use of corrective equipment. In the present article the use of corrective equipment is explained. A succeeding article will take up the question of how far it pays to go in correctingthe power factor of an industrial plant load.

Practical pointers on

Methods of Correcting Power Factor

of industrial plant loads by the use of equipment that has been designed for this purpose

By JAMES B. HOLSTON
Commercial Engineer, Wagner Electric Corporation, St. Louis, Mo.

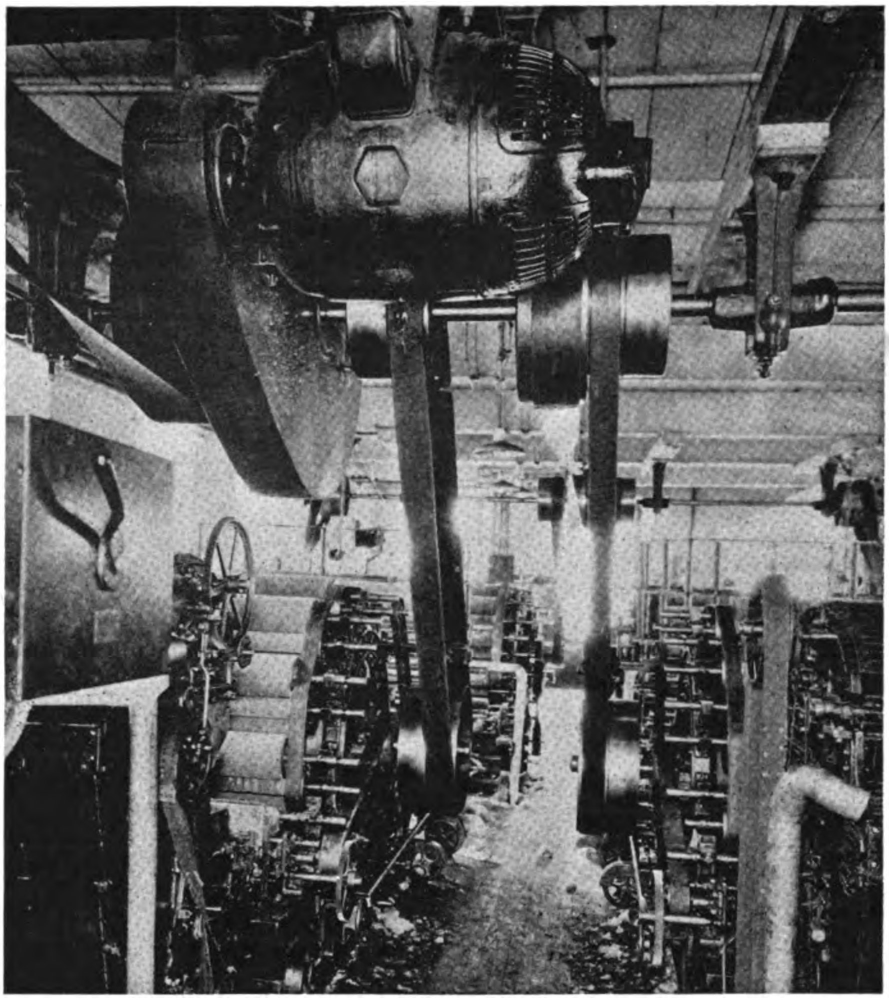


Fig. 1—This shows a 25-hp., 1,200-r.p.m., 220-volt, two-phase, 60-cycle Fynn-Weichsel motor driving a line-shaft through a silent chain, in the plant of the Byrne and Hance Spinning Co., Philadelphia, Pa.

IN THE previous article, on page 356 of the August issue, the possibility of raising the power factor of an industrial plant, by rearranging induction motors so that they will be properly loaded, was discussed in detail.

After having made load tests on all motors except those operating only intermittently, and rearranging and replacing them to get better load factors and consequently better power factors, the operating engineer faces the problem of selecting suitable equipment to further increase the plant power factor from 75 or 80 per cent up to 90, 95, or possibly 100 per cent.

Engineers frequently make the statement that it is uneconomical to raise power factor higher than 90 or 95 per cent. Before setting any figure as a definite limit, however, it seems best to consider all of the various factors which may be involved. Where a large number of induction motors are included in the plant load, the cost of correction beyond 90 per cent may not be justified. On the other hand, where a single large unit consumes the greater part of the power, and a synchronous or Fynn-Weichsel type motor can be used for this drive, correction to 100 per cent may be accomplished at no greater cost than 95 or even 90 per cent correction.

The solution of the power factor problem consists largely in eliminating or balancing induction motor magnetizing currents. If a part of the induction motors are replaced by motors which not only supply their own magnetizing current, but also an excess available for the remaining induction motors, it follows that the amount of correction required is less than if no motors are replaced and condensers are used to correct the entire load. This fact is important and should be thoroughly understood before any selection of corrective equipment is made.

According to a splendid treatise published by the National Electric Light Association, and dated January, 1926, power factor correction may be accomplished by means of four different types of equipment: synchronous motors, Fynn-Weichsel motors, static condensers and synchronous condensers. The following discussion will deal with each of these types of equipment in the order named.

Synchronous Motors—Synchronous motors afford an excellent means of correcting power factor in the larger plants where motors of 50 hp. and over are used. General-purpose motors are usually of the induction type, but for air compressors (provided mechanical unloaders are used), blowers, pumps, motor-generator sets, drives requiring several hundred horsepower, and similar applications, where the starting torque required is less than 50 per cent of full-load torque and where the motors are running for long periods of time, the straight synchronous-type motor is well suited. Synchronous motors are built in three ratings—80 per cent, 90 per cent (leading power factor) and 100 per cent, or unity power factor. The 80 and 90 per cent motors are used for power

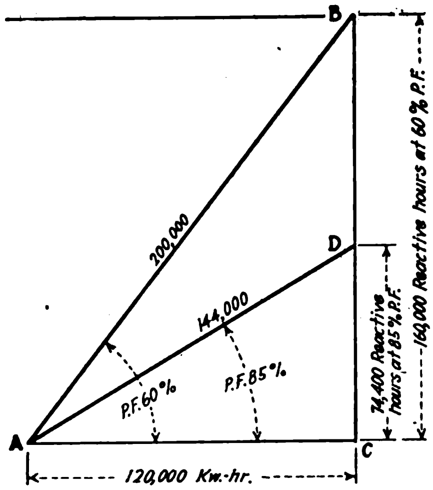


Fig. 2—Substituting 350 hp. in synchronous motors for induction motors raised the power factor from 60 per cent to 85 per cent.

The original conditions are represented by the triangle whose sides are *ABC*. With meter readings of 120,000 kw.-hr. and 160,000 reactive hours, the power factor was 60 per cent. The installation of 350 hp. in synchronous motors gave the conditions shown by triangle *ADC*, where a consumption of 120,000 kw.-hr. with a reduction to 74,400 reactive hours gave a resultant power factor of 85 per cent.

factor correction. In some cases over-size motors are installed and operated at reduced loads in order to obtain a greater corrective effect. This practice is not generally to be recommended, however, as it means a sacrifice in operating efficiency. Using properly rated motors in sufficient numbers to correct the power factor to the desired point is much more efficient, although it is slightly more expensive from the standpoint of initial investment. Frequently the use of 90 per cent power factor motors is preferred to the 80 per cent type, because of the smaller line current drawn by the former. This is especially true where induction motors are replaced by the synchronous type in old installations, as new feeders would be required with the 80 per cent motors.

The size of the synchronous motors required can be calculated if the total kilowatt hours consumed per month and the effective power factor are known. Referring to Fig. 2, assume that the kw.-hr. are 120,000 and the power factor is 60 per cent. In order to determine the size of synchronous motors to be substituted for induction motors in order to correct the power factor to 85 per cent, the number of "reactive-hours" is first computed. In Fig. 2, side *BC* represents the "reactive-hours" at 60 per cent power factor. As explained in the articles in the July and August issues,

$$BC = \sqrt{AB^2 - AC^2}$$

and $AB = AC \div$ power factor $=$

$$120{,}000 \div .60 = 200{,}000$$

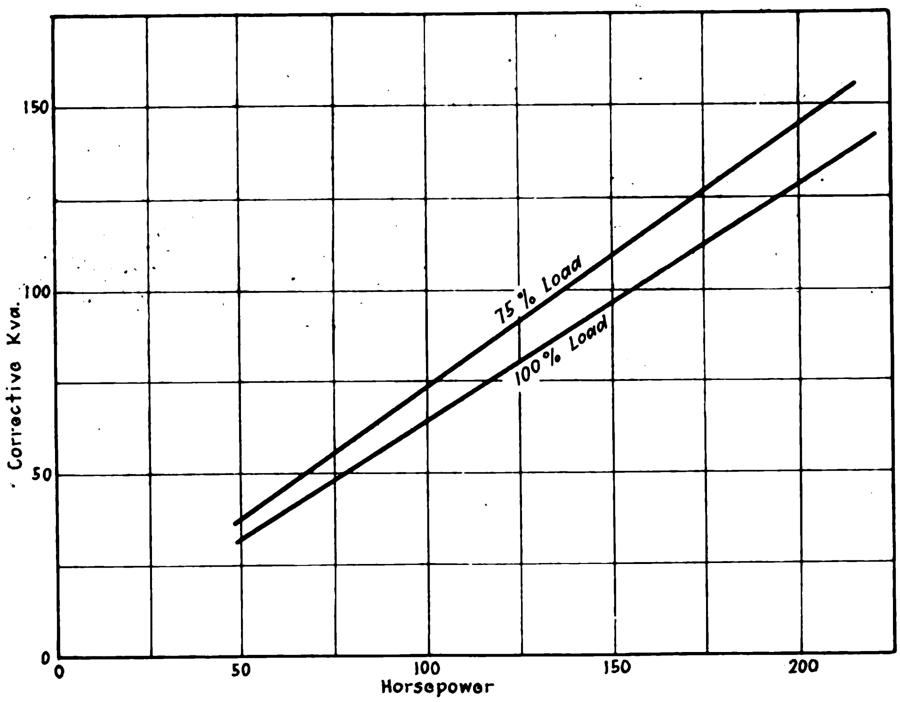
$$\text{Therefore, } BC = \sqrt{(2^2 - 1.2^2) \times 10^{10}} = 160{,}000$$

Referring to the chart on page 310 of the July issue, showing the ratio of reactive hours to kilowatt-hours, or to the curve on page 356 of the August issue, the ratio of reactive hours to kilowatt-hours at 60 per cent power factor is found to be 1.33. Therefore, the reactive hours should equal 1.33 $\times$ 120,000, or 160,000, which checks with the calculations made before.

At 85 per cent power-factor *DC* represents the reactive hours and is found to be 74,400, when computed in the same manner as *BC*. Subtracting *DC* from *BC* (160,000 — 74,400) leaves 85,600 reactive hours. In short, to correct the power factor from 60 per cent to 85 per cent 85,600 reactive hours must be eliminated. Normal plant operation being 250 hr. per month, the average reactive kva. required is 85,600 divided by 250, or 342 reactive kva.

With 90 per cent efficiency and 80 per cent leading power factor at full load, synchronous motors will de-

Fig. 4—These curves show the corrective kva. capacity of 80 per cent leading-power-factor synchronous motors.



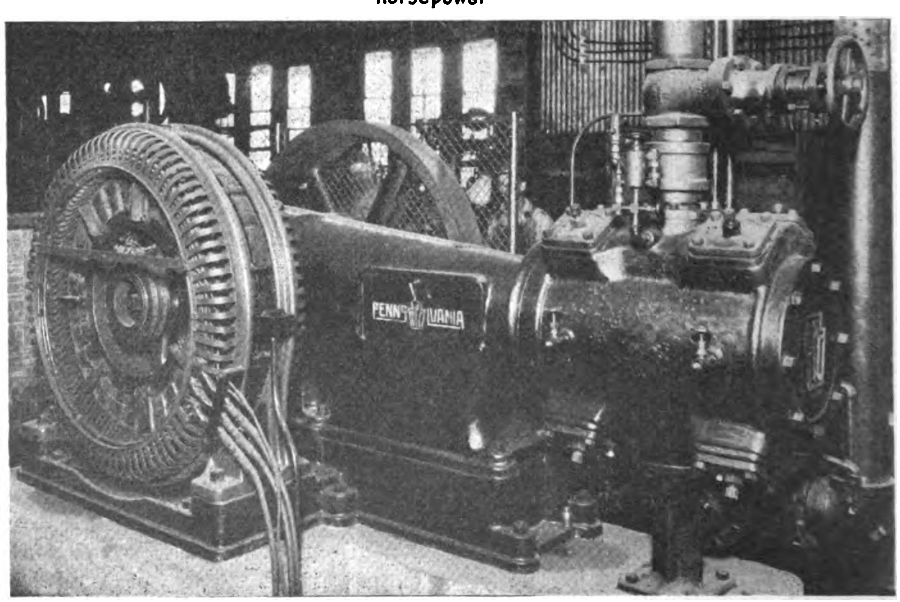


Fig. 3—Synchronous motors can usually be used to advantage on air compressor drives.

This is an Electric Machinery Mfg. Co., unity-power-factor synchronous motor which is rated at 100 hp., 60 cycles, 220 volts, 257 r.p.m. It is direct-connected to a standard air compressor in the plant of the St. Louis Frog & Switch Co., St. Louis, Mo.

liver .62 reactive kva. per horsepower. Large induction motors will require .36 reactive kva. per horsepower, at 90 per cent efficiency and 92 per cent power factor. Therefore, the synchronous motor horsepower required when substituted for induction motors is equal to 342 ÷ .62 + .36 = 349 hp.

Fig. 4 shows the corrective kva. of 80 per cent power factor synchronous motors, and affords a convenient means of calculating the sizes required. In the present case the curve shows that a 100-hp. motor supplies 62 reactive kva. at 100 per cent load. In other words, an 80 per cent power factor motor supplies .62 reactive kva. per horsepower, regardless of motor size. Similarly, Fig. 5 shows that a 100-hp. induction motor at full load requires 36 reactive kva., or .36 reactive kva. per horsepower. By making use of these two curves the calculations can be made quite easily.

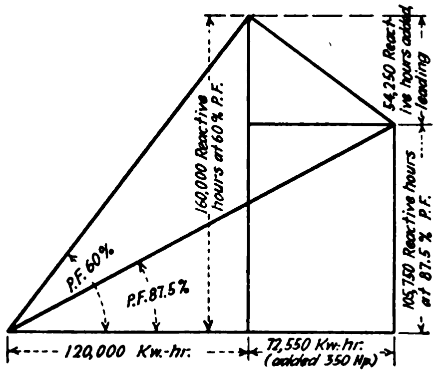
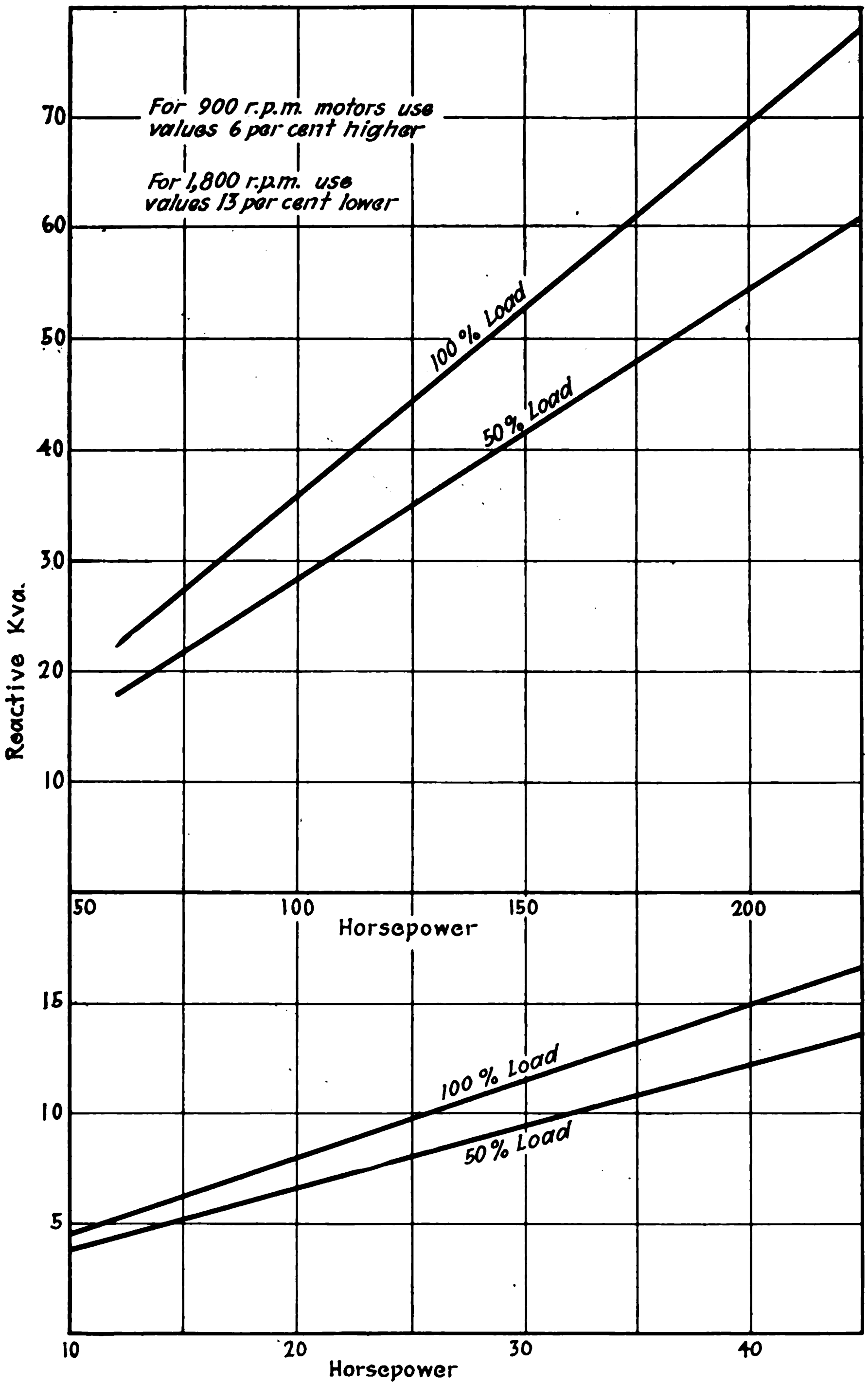


Fig. 6—In this case adding a 350-hp. synchronous motor to an existing installation of induction motors raised the power factor from 60 per cent to 87.5 per cent.

Fig. 5—Reactive kva. of 1,200-r.p.m., squirrel-cage, polyphase, induction motors.



In the case given above the horsepower required was found to be 349. In order to allow for load factors and other variables, 375 hp. of motors should be changed. It is interesting to note that the calculations show the corrective kva. required to be just about equal to the horsepower of motors to be changed. This may be followed as a general rule in making hurried or approximate estimates. The largest units should always be changed; for example, in the case given above it would be best to change one 200-hp. and one 175-hp. unit, if such sizes are present. The reason for this is that the cost per corrective kva. is always less in the larger units than in the smaller sizes. Operating advantages favor the smaller units, but inasmuch as the synchronous motors are not available except in the larger sizes, this consideration need not enter into the discussion.

It will be noted that the above explanation is founded upon the "reactive hour-kilowatt-hour" system of metering. In case the power rate is based upon the kva. demand, or power is obtained from the consumer's own generating equipment, the same reasoning applies, but the values of the various sides of the power factor triangle, shown in Fig. 2, will be expressed in kw., reactive kva., and kva., rather than kw.-hr., reactive hours, and kva.-hr. Values for maximum demand should be used.

In case a synchronous motor is to be added to the present load, instead of being substituted for an existing motor, it may be desirable to calculate the resultant power factor. Referring to Fig. 6, the same data are used as for Fig. 2, except that it is assumed that a 350-hp., 80 per cent synchronous motor is to be added to the load.

For 250 hr. operation per month, a 350-hp. motor delivers 54,250 reactive hours leading (250 × 350 × .62). Then subtracting 54,250 from 160,000 leaves 105,750 reactive hours. The kilowatt-hours are increased by

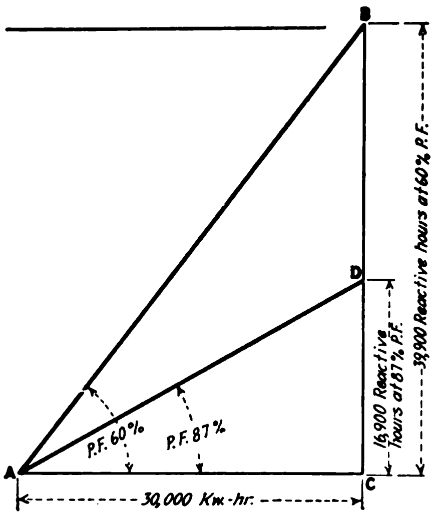


Fig. 7—Substituting 105 hp. in Fynn-Weichsel motors raised the power factor of this load from 60 per cent to 87 per cent.

the amount used by the added motor,
250 × 350 × .746 ÷ .90 = 72,550
In the above formula .746 is the factor for converting from horsepower to kilowatts, and .90 is the motor efficiency. The resultant power factor can now be found from the ratio of reactive hours to kilowatt-hours. As the ratio is 105,750 divided by (120,000 plus 72,550), or .55, the power-factor is found from the chart to be 87.5 per cent.

Attention is directed to the fact that if a unity power factor synchronous motor is added to the above load the power factor will be raised, as the kilowatt-hour component is increased and the ratio of reactive hours to kilowatt-hours is made less. In this particular case, the reactive hour component would remain the same (160,000), but the kilowatt-hours would be increased to 192,550. The power factor corresponding to the ratio of 160,000 divided by 192,550 (.832) is 77 per cent, as compared to 60 per cent before installation of the 350-hp. unit. Similarly, if an electric furnace load of 290 kw. (equivalent to 350 hp. in motors) at 100 per cent power factor is added, the power factor would be raised from 60 per cent to 77 per cent.

Fynn-Weichsel Motors—Fynn-Weichsel motors may be used for power factor correction and have a wide application because of their high starting torque, induction motor range of sizes, and simple operating requirements. These motors start on the slip-ring induction motor principle and have starting torques ranging from 150 per cent of full-load torque up to much higher values in some ratings. Many plants have applications where synchronous motors cannot be used on account of starting requirements. Often, too, there are no large units which can be changed to corrective motors, and in such cases a number of the smaller Fynn-Weichsel motors can be used to accomplish the desired result. Standard-type, slip-ring starting equipment is used and can be operated by anyone familiar with induction motor control.

The same methods are used to determine the size of Fynn-Weichsel motors required as have been explained for the synchronous motors. It will be noted from Fig. 8 that in comparable sizes the corrective ef-

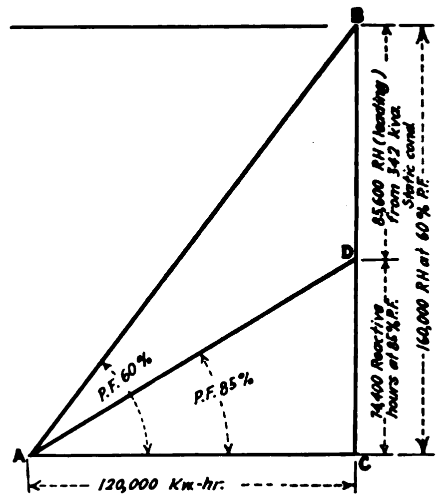


Fig. 9—Installation of a 342-kva. static condenser raised the power factor of this system from 60 per cent to 85 per cent by supplying 85,600 reactive hours (leading).

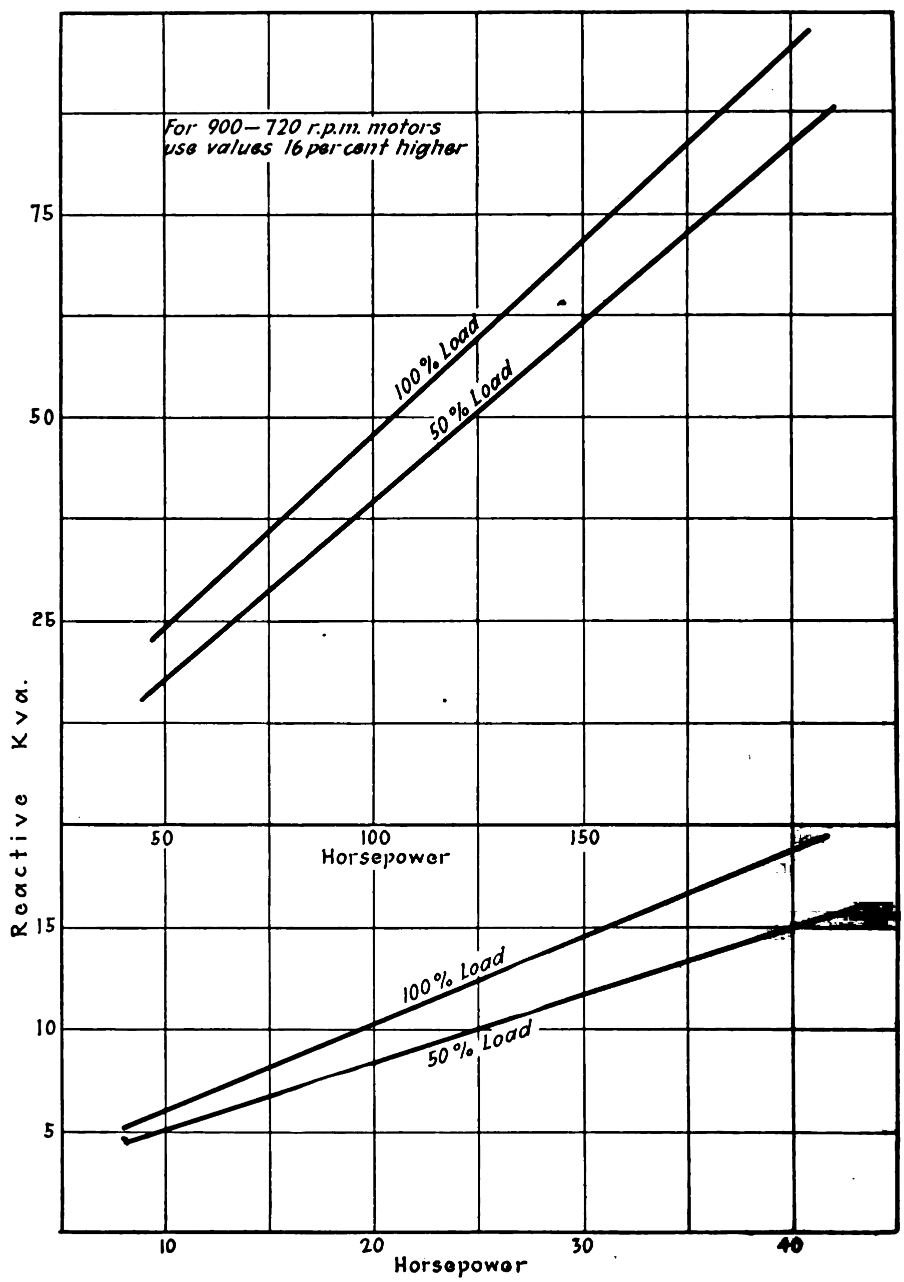
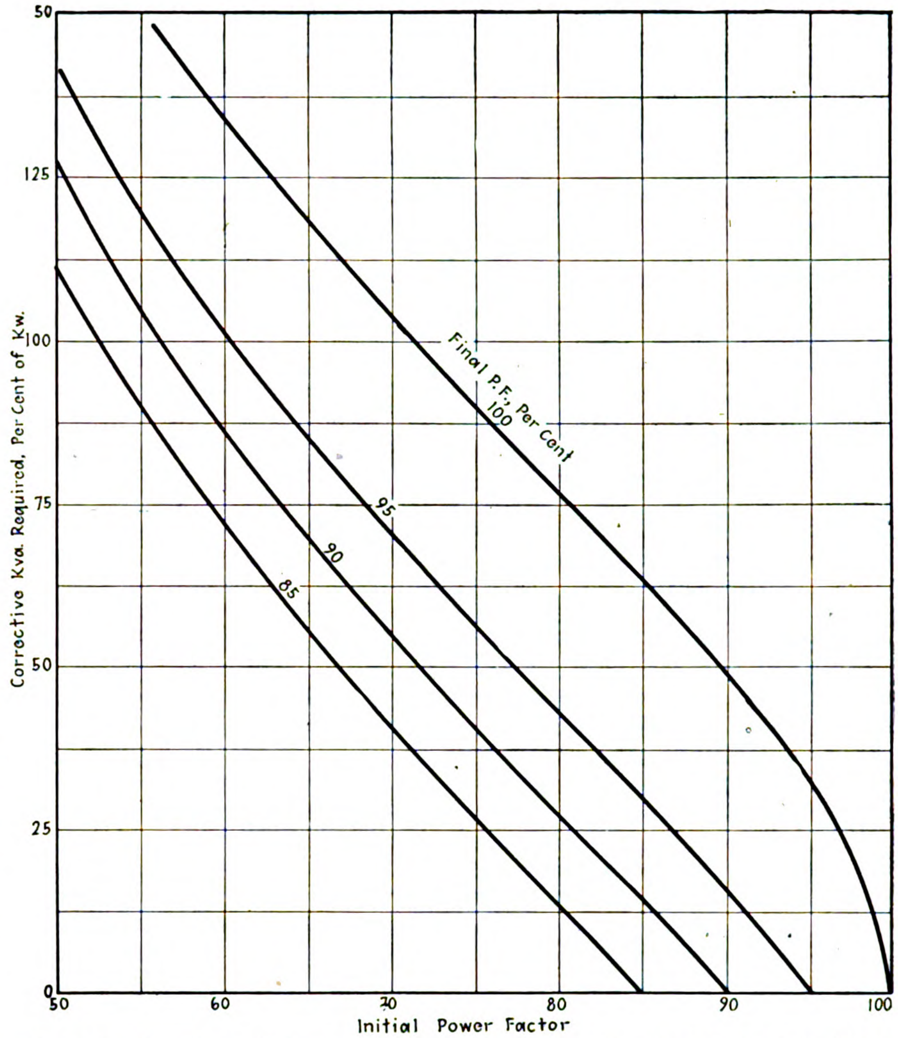


Fig. 8—This shows the corrective kva. capacity of 1,200-r.p.m. Fynn-Weichsel motors.

Fig. 10—The kva. required to raise the power factor to any desired value may be determined from this chart.

Locate on the bottom line the figure corresponding to the present power factor; then follow this vertical line up to the point where it intersects the curve corresponding to the desired power factor (85, 90, etc., per cent). Follow this point of intersection horizontally to the corresponding figure at the left, which represents the reactive kva. required, in terms of per cent of kilowatts.



fect of these motors and synchronous motors is much the same, whereas the smaller Fynn-Weichsel motors operate at a power factor of about 90 per cent, and, therefore, supply a smaller amount of corrective effect.

A typical case where Fynn-Weichsel motors are used for power factor correction is one where one 75-hp. and two 15-hp. motors were substituted for induction motors. This load is represented by Fig. 7. Using Fig. 5, the lagging reactive kva. of each 15-hp. induction motor is 6 and of the 75-hp. induction motor, 28. Fynn-Weichsel motors of corresponding horsepower have 8 reactive kva. (leading) for the 15-hp. size and 36 reactive kva. for the 75-hp. unit, according to Fig. 8. Adding lagging and leading reactive kva. (12 + 28 + 16 + 36) gives a total of 92. For 250 hr. operation per month, the total reduction in reactive hours is 250 × 92 = 23,000. The reactive hours at 60 per cent power factor for 30,000 kw.-hr. are 39,900. The substitution of the three Fynn-Weichsel motors reduces this to 39,900 — 23,000 = 16,900 reactive hours; and the power factor corresponding to the ratio of 16,900 divided by 30,000 (.563) is 87 per cent.

If the same Fynn-Weichsel motors were added to this load, instead of being substituted for other motors, the power factor would be raised to 89 per cent, as the reactive hours would be reduced by 250 × (36 + 2 × 8) = 13,000, and the kilowatt-hours would be increased by 250 × (105 × .746) ÷ .88 = 22,250. The ratio of reactive hours to kilowatt-hours is (39,900 — 13,000) ÷ 30,000 + 22,250 = .515.

Therefore, power factor equals 89 per cent.

An addition to a plant may include a number of motors, part of which can be of the corrective type, while the others must be of the induction type for operating reasons. In such cases the lagging reactives of the induction motors and the leading reactives of the corrective motors can be calculated and the resultant power factor found.

Static and Synchronous Condensers—When it is undesirable to replace induction motors with the power-factor-correcting types, on account

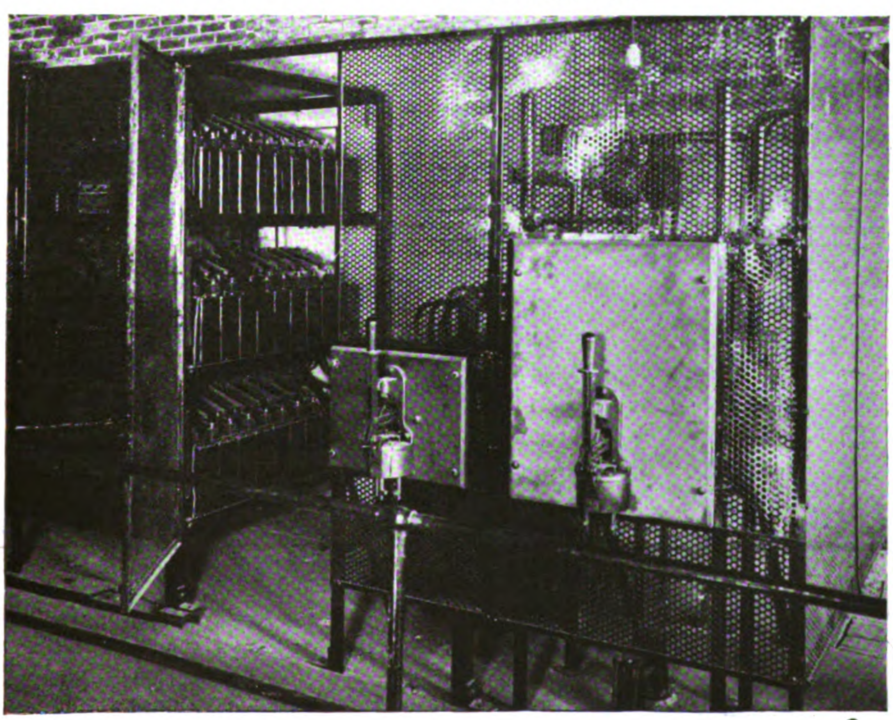


Fig. 11—Here is an instance where a static condenser is used to raise power factor.

This illustration shows one, three-phase, 60-cycle, 180-kva., 2,300-volt Capacitor (General Electric Co.) installed by the Electric Autolite Co., Fostoria, Ohio.

of operating difficulties (such as are encountered in metal working plants, for instance, where the abrasive dust might preclude the use of any but squirrel-cage type motors) or for any other reason, static condensers can best be used. The multiple-unit type is preferred to the individual-motor type on account of lower initial and maintenance costs, as well as installation and operating considerations. Both the 2,300- and 400-volt types are available. The lower-voltage condensers are preferred, as the low power factor is corrected before it reaches the transformers. However, the losses chargeable to the condenser are between 2½ and 3 per cent with the low-voltage type, as an auto-transformer is required, whereas the 2,300-volt units have only about ½ per cent loss. Recently low-voltage condensers operating without transformers have been developed, and will probably take the place of the 2,300-volt units.

Referring to Fig. 9, a load of 120,000 kw.-hr. at 60 per cent power factor has 160,000 reactive hours. The same load at 85 per cent power factor has 74,400 reactive hours. Then 160,000 minus 74,400 is 85,600, which must be supplied by a static condenser to raise the power factor from 60 per cent to 85 per cent. Assuming 10 hr. operation per day and 25 days per month, the size of condenser required is equal to

$85{,}600 \div (25 \times 10) = 342$ kva.

With 2½ per cent loss and power costing 2 cents per kw.-hr., the monthly operating cost of such a condenser is $.025 \times 342 \times 250 \times .02 = \$42.75$, or $513 per year.

In case the condenser were operated 24 hrs. per day and 30 days per month the size required would be, $85{,}600 \div (24 \times 30) = 119$ kva.

It should again be noted that the above calculations are based upon the "reactive hour-kilowatt-hour" system of metering. If the power factor at the time of maximum demand is to be raised, the term "hours" should be omitted from the calculations and the values of power factor, kilowatts and reactive kva. taken at the time the maximum is created.

Fig. 10 shows a simplified method of calculating condenser sizes required to raise the power factor from one point to another. For example, assume that the monthly kilowatt-hours are 100,000 and the power factor 80 per cent, and it is desired to raise the power factor to 100 per cent. The intersection of the vertical line of 80 per cent initial power factor with the line of 100 per cent final power factor is at the 75 per cent line corresponding to "corrective kva. required in per cent of kw." Therefore, the reactive hours required to raise the power factor from 80 per cent to 100 per cent are 75 per cent of 100,000, or 75,000. At 250 hr. operation per month this would mean that a 300-kva. condenser is needed. Following the same method of reasoning, a 1,000-kw. load requires a 750-kva. condenser to raise the power factor from 80 per cent to 100 per cent.

The size of synchronous condenser required for power factor correction can be calculated in exactly the same manner as was described for static condensers (neglecting the effect of the condenser losses on the power factor, which is small).

The use of synchronous condensers in industrial plants is seldom justified on account of the heavy operating expense, rotating condensers having losses ranging from 5 to 10 per cent of rated capacity. Unless power is unusually low priced the cost of operation is excessive and one of the three other methods of correcting power factor will usually be found best. Sometimes there are available unused synchronous motors which can be converted into synchronous condensers quite easily; in such cases their use may be economical, although this is somewhat doubtful.

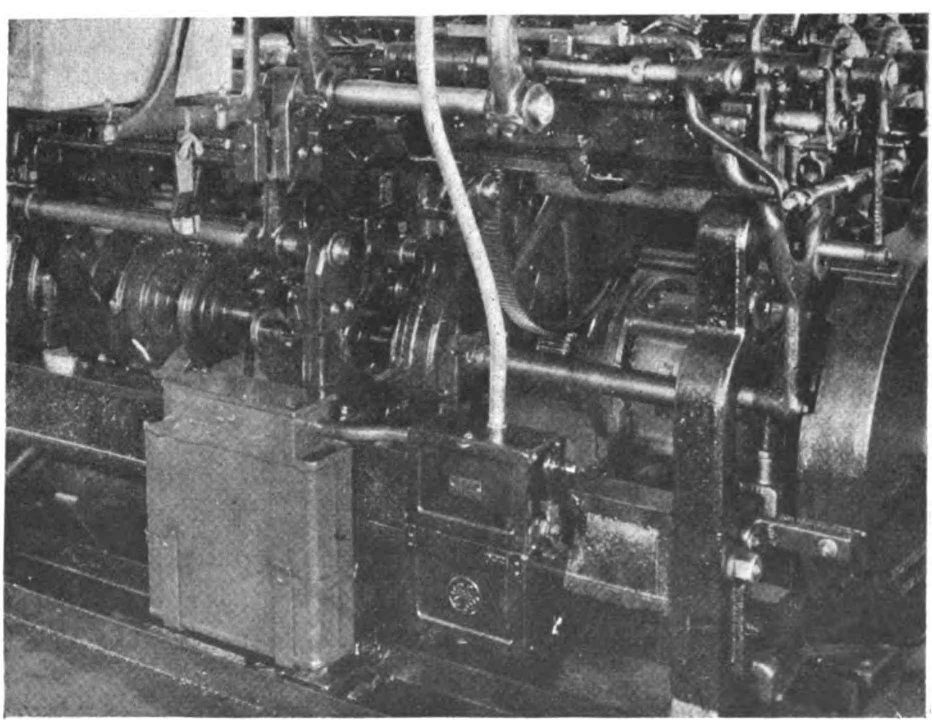
It is frequently found that the use of two or more types of corrective equipment is required in a plant to obtain power factor correction most economically. Conditions may be such that the number of motors which can be changed to the corrective type is not sufficient to give all of the correction required, and the use of a condenser in addition to such motors as may be changed will give the required correction.

Although it is not within the province of this article to point out the advantages of electric heating as applied to industrial processes, it may not be out of place to mention again the fact that all resistance-type heating equipment operates at unity power factor and helps to raise the power factor of a plant system by increasing the kilowatt-hour consumption, while the reactive hours will remain the same. If the nature of the manufacturing processes is such that electric heating equipment can be employed to advantage, its use should be considered.

In any case it is necessary to make a careful study of all of the various factors that have a bearing on the problem, before definitely selecting the methods and equipment to be employed in raising the power factor.

A subsequent article that will appear in an early issue will discuss in detail the question of how high it pays to correct power factor.

Fig. 12—In this case an individual static condenser is installed for each motor.
The low-voltage Capacitor shown here is installed to correct the power factor of the motor which drives a full-fashioned hosiery machine.



Insulation on Magnet Wire for Repair Shop Work

together with handy tables that will help in replacing round wire with square wire of the desired carrying capacity and type of insulation.

By A. C. ROE
and
D. H. BRAYMER,
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WHEN rewinding motor and magnet coils it is frequently necessary to make changes in the wire sizes or kind of insulation used, in order to reduce the operating temperature, or get a certain number of conductors in a given slot space. In this article some of these different conditions are discussed and tables given from which information can quickly be obtained on the possible standard sizes of wire to use and the insulation that can be employed.

IN THE August issue, data on the wire used in repair work were presented. In this article the subject of insulation is discussed from the standpoint of adequate insulation for different work, and the substitution of different insulation so as to meet the space, dielectric and temperature requirements of difficult jobs calling for changes in wire sizes or their normal carrying capacity.

Single - Cotton - Covered Wire.—Single-cotton-covered magnet wire has a small field of application, as the single covering provides very little added insulation and its mechanical protection is low. Its use is confined to small shunt field coils that have a large number of turns and are wound to final shape; that is, coils that are wound straight and not bent. A good grade of enameled wire is preferred in repair work for replacing small coils wound only with single-cotton-covered wire.

Double-cotton-covered magnet wire is the most widely used in the construction and repair of electrical apparatus, and is made up as round, square and ribbon wire. The covering consists of a good quality of unbleached cotton yarn, applied in two layers. The layers are put on in opposite directions so that both cannot be unwound at once, the top layer being unwound in a clockwise direction and the bottom layer in a counter-clockwise direction. Each wrapping should be firmly applied, be continuous and free from lumpy splices, and when bent around ⅛-in. radius at 90 deg., the copper should not show through.

The mandrel test as explained for enameled wire (August issue, page 364) can be applied to d.c.c. wire for breaking down to ground, one layer, and between layers. The total thickness of insulation between both walls will vary from .009 in. to .018 in. according to the size and kind of wire. In gaging insulated wire a slight pressure should be used with the micrometer.

In the article that appeared in the August issue (page 366), Table IV showed the insulated size of d.c.c. round wires. Table I of this article gives the total insulated size in decimals and fractions for d.c.c. round wires, from No. 4-0 to No. 19 B & S gage. The first vertical column lists the size of the wire in the B & S gage number. Then the top horizontal line gives the number of wires for which it is desired to know the space required for a given number of wires lying side by side.

For example, assume that we have a puller coil wound with eight turns of three No. 9 d.c.c. wires. It is desired to know: (1) The wire space

Table I—Wire Table for Figuring Coil Size and Shellacked Strips When Using D.C.C. Round Copper Wire

No. of Wires	1		2		3		4		5		6		7		8		9		10	
Size Wire	D	F	D	F	D	F	D	F	D	F	D	F	D	F	D	F	D	F	D	F
4-0	.478	15/32	.956	61/64	1.434	1 27/64	1.912	1 29/32	2.39	2 25/64	2.86	2 55/64	3.34	3 21/64	3.82	3 13/16	4.30	4 19/64	4.78	4 3/4
3-0	.428	27/64	.856	27/32	1.284	1 9/32	1.712	1 45/64	2.24	2 15/64	2.56	2 9/16	2.94	2 15/16	3.42	3 27/64	3.85	3 27/32	4.28	4 9/32
2-0	.383	3/8	.766	3/4	1.149	1 9/64	1.532	1 17/32	1.915	1 29/32	2.29	2 9/32	2.68	2 43/64	3.06	3 1/16	3.44	3 7/16	3.83	3 53/64
0	.343	21/64	.686	43/64	1.029	1 1/32	1.372	1 3/8	1.715	1 45/64	2.05	2 3/64	2.401	2 25/64	2.74	2 47/64	3.08	3 5/64	3.43	3 27/64
1	.307	19/64	.614	39/64	.921	59/64	1.228	1 7/32	1.53	1 33/64	1.84	1 53/64	2.14	2 9/64	2.45	2 29/64	2.76	2 49/64	3.07	3 1/16
2	.276	17/64	.552	35/64	.828	53/64	1.104	1 3/32	1.372	1 3/8	1.65	1 41/64	1.93	1 59/64	2.20	2 13/64	2.48	2 15/32	2.76	2 3/4
3	.247	1/4	.494	1/2	.741	47/64	.988	63/64	1.235	1 15/64	1.48	1 15/32	1.72	1 23/32	1.97	1 31/32	2.22	2 7/32	2.47	2 15/32
4	.222	7/32	.444	7/16	.666	21/32	.888	57/64	1.110	1 7/64	1.33	1 21/64	1.55	1 35/64	1.77	1 49/64	1.99	2	2.22	2 7/32
5	.199	3/16	.398	25/64	.597	19/32	.796	51/64	.995	63/64	1.19	1 3/16	1.39	1 25/64	1.59	1 37/64	1.79	1 25/32	1.99	1 63/64
6	.178	11/64	.356	11/32	.534	17/32	.712	45/64	.890	57/64	1.06	1 1/16	1.24	1 15/64	1.42	1 27/64	1.60	1 19/32	1.78	1 49/64
7	.160	5/32	.320	5/16	.480	15/32	.640	41/64	.800	51/64	.960	61/64	1.12	1 7/64	1.28	1 9/32	1.44	1 7/16	1.60	1 19/32
8	.143	9/64	.286	9/32	.429	27/64	.572	9/16	.715	45/64	.858	27/32	1.00	1	1.14	1 9/64	1.28	1 9/32	1.43	1 27/64
9	.126	1/8	.252	1/4	.378	3/8	.504	1/2	.630	5/8	.756	3/4	.882	7/8	1.00	1	1.13	1 1/8	1.26	1 1/4
10	.112	7/64	.224	7/32	.336	21/64	.448	7/16	.560	9/16	.672	43/64	.784	25/32	.896	57/64	1.00	1	1.12	1 7/64
11	.101	3/32	.202	13/64	.303	19/64	.404	25/64	.505	1/2	.606	19/32	.707	45/64	.808	51/64	.909	29/32	1.01	1
12	.091	5/64	.182	11/64	.273	17/64	.364	23/64	.455	29/64	.546	17/32	.637	5/8	.728	23/32	.819	13/16	.91	29/32
13	.082	5/64	.164	5/32	.246	1/4	.328	21/64	.410	13/32	.492	31/64	.574	9/16	.656	21/32	.738	47/64	.82	13/16
14	.073	1/16	.147	9/64	.219	7/32	.292	9/32	.365	23/64	.438	7/16	.511	1/2	.584	37/64	.657	21/32	.73	23/32
15	.066	1/16	.132	1/8	.198	3/16	.264	17/64	.330	21/64	.396	25/64	.462	29/64	.528	33/64	.594	19/32	.66	21/32
16	.059	3/64	.119	7/64	179	11/64	.239	15/64	.299	19/64	.358	23/64	.418	13/32	.478	15/32	.538	17/32	.598	19/32
17	.054	3/64	.108	7/64	.162	5/32	.2168	7/32	.271	17/64	.355	11/32	.379	3/8	.433	27/64	.487	1/2	.542	17/32
18	.049	3/64	.098	3/32	.148	9/64	.197	3/16	.246	15/64	.295	9/32	.345	11/32	.394	25/64	.443	7/16	.493	31/64
19	.044	3/64	.089	5/64	.134	1/8	.179	11/64	.224	7/32	.259	1/4	.314	5/16	.359	23/64	.404	25/64	.449	7/16

The first column gives the B & S gage; the top line gives the number of wires wide and under each number of wires wide is given the width in decimals and the nearest smaller fraction. D=Decimal. F=Fraction.

Table III—Winding Data for Square D.C.C. and T.C.C. Copper Magnet Wire

B & S Gage Size	Bare Diameter Inches	Radius of Corners	Area of Copper: Circ. Mils	Area of Copper: Square Inches	Per Cent Increase Cross Sectional Area Copper	D.c.c. Insulation Diam.	T.c.c. Insulation Diam.
0000	.460	1/16	265,152	0.20825	25.3	0.483	0.497
000	.410	1/16	209,345	0.16442	24.75	.433	.442
00	.365	1/16	165,037	0.12972	24.00	.388	.397
0	.325	1/16	130,124	0.10220	23.34	.348	.357
1	.289	1/16	102,292	0.08034	22.23	.312	.321
2	.258	1/16	80,203	0.06300	20.84	.281	.290
3	.229	1/16	62,732	0.04927	19.20	.252	.261
4	.204	3/64	50,737	0.03985	21.56	.227	.236
5	.182	3/64	39,725	0.03120	20.00	.205	.214
6	.162	1/32	32,340	0.02540	23.20	.183	.191
7	.144	1/32	25,439	0.01998	22.18	.163	.171
8	.129	1/32	19,951	0.01567	20.84	.146	.153
9	.114	.02	16,221	0.01274	23.90	.129	.135
10	.102	.02	12,783	0.01004	23.15	.115	.120
11	.0907	.02	10,033	0.00788	21.84	.103	.108
12	.0808	.02	7,868	0.00618	20.49	.093	.098
13	.0720	.02	6,162	0.00484	19.00	.083	.088

required in the shuttle for three No. 9 d.c.c. wires. (2) The puller jaw space for No. 9 d.c.c. wires placed eight deep and three wide. This information is found as follows: Consult Table I and find No. 9 d.c.c. size in the first column. In the column marked 3, we find .378 and the nearest fraction 3/8 in., which is the width required for three wires wide. From the column marked 1, the depth for eight No. 9 d.c.c. wires is found to be 8 x 1/8 in. or 1.00 in. space. The fraction column gives the nearest smaller fraction, the smaller size being selected to permit of the table being used to give the size of shellacked strips in fractions. Since these strips are used to cement the wires together under pressure (as will be explained in a later article on coil construction) these strips must not project beyond the coil wall.

Table II gives data for square d.c.c. wire and corresponds to Table I, except that the figures differ due to a slight increase in the insulation used on square wire.

Table III gives the maximum insulated sizes of square d.c.c. and t.c.c. (triple-cotton-covered) magnet wire. Column 6 of Table III gives the per cent increase in copper gained by substituting a square wire for the corresponding round wire. For example, a No. 10 round wire has an area of 10,280 circ.mils and a No. 10 square wire an area of 12,783 circ.mils, or an increase in copper of 23.15 per cent.

Table III and Table IV (August issue, pages 365 and 366 will be useful in making up coils of any description for magnets, fields, or armatures. For example, assume that a machine runs hot and, while rewinding, we find the armature was wound with No. 8 round wire and the shunt field with No. 13 d.c.c. round wire. By using No. 8 square wire we gain 20.84 per cent copper in the armature, and by using No. 13 square wire, if the room permits, in the field coil, we gain 19 per cent more copper, which will cool the motor down considerably. The lower resistance of the field will affect the regulation, but this can be taken care of without any appreciable trouble. The square wire in the armature coil will not call for a change in the commutator slotting, but care must be taken that the wire has its right and left sides vertical before attempting to drive it into the commutator neck, and also in winding the coil. Fig. 1 explains the reasons for the above statement. In Fig. 1*A* a round wire 1/2 in. in diameter is shown, and in Fig. 1*B* a square wire is shown. The 1/2-in. side of the square wire is equal to the diameter of the round wire, but the diagonal dimension of the square wire is equal to the square root of the flat dimension, or .707 in. and would not go in a 1/2-in. slot.

When winding coils with square wire it is important to watch the Nos. 13, 12, 11 and 10 B & S gage sizes, for these smaller sizes are hard to keep flat while winding. When they are not kept flat the condition shown in Fig. 1*C* will be the result. The corners tend to cut into the upper and lower turns and the danger of shorts between turns is increased. Also, the width and depth of the coil is increased, depending on the angle of twist.

Table IV gives the bare and insulated sizes of d.c.c. ribbon wire and also the area in circ.mils and square inches. The bare wire sizes are

Table II—Wire Table for Figuring Coil Size and Shellacked Strips When Using D.C.C. Square Copper Wire

No. of Wires	1		2		3		4		5	
B & S No.	D	F	D	F	D	F	D	F	D	F
4-0	.483	31/64	.966	61/64	1.449	1 7/16	1.93	1 59/64	2.41	2 13/32
3-0	.433	27/64	.866	55/64	1.299	1 19/64	1.73	1 47/64	2.16	2 5/32
2-0	.388	25/64	.776	49/64	1.164	1 5/32	1.55	1 35/64	1.98	1 31/32
0	.348	11/32	.696	11/16	1.04	1 1/32	1.39	1 25/64	1.74	1 47/64
1	.312	5/16	.624	5/8	.936	15/16	1.24	1 1/4	1.56	1 9/16
2	.281	9/32	.562	9/16	.843	27/32	1.12	1 1/8	1.40	1 13/32
3	.252	1/4	.504	1/2	.756	3/4	1.00	1	1.26	1 1/4
4	.227	7/32	.454	29/64	.686	11/16	.908	29/32	1.13	1 1/8
5	.205	13/64	.410	13/32	.615	39/64	.820	13/16	1.02	1 1/64
6	.183	11/64	.366	23/64	.549	35/64	.732	47/64	.915	29/32
7	.163	5/32	.326	21/64	.489	1/2	.652	41/64	.815	13/16
8	.146	9/64	.292	9/32	.438	7/16	.584	37/64	.730	23/32
9	.129	1/8	.258	1/4	.387	3/8	.516	33/64	.640	41/64
10	.115	7/64	.230	7/32	.345	11/32	.460	29/64	.575	9/16
11	.102	3/32	.204	13/64	.306	19/64	.408	13/32	.510	1/2
12	.092	3/32	.184	11/64	.276	17/64	.368	23/64	.460	29/64
13	.083	5/64	.166	5/32	.249	1/4	.332	21/64	.415	13/32

No. of Wires	6		7		8		9		10	
B & S No.	D	F	D	F	D	F	D	F	D	F
4-0	2.90	2 57/64	3.38	3 3/8	3.86	3 55/64	4.34	4 21/64	4.83	4 53/64
3-0	2.60	2 19/32	3.03	3 1/32	3.46	3 29/64	3.90	3 57/64	4.33	4 21/64
2-0	2.33	2 21/64	2.76	2 3/4	3.10	3 3/32	3.49	3 1/2	3.88	3 7/8
0	2.09	2 3/32	2.43	2 7/16	2.88	2 7/8	3.13	3 1/8	3.48	3 15/32
1	1.87	1 7/8	2.18	2 11/64	2.49	2 31/64	2.80	2 51/64	3.12	3 1/8
2	1.68	1 43/64	1.96	1 61/64	2.24	1 1/2	2.52	2 33/64	2.81	2 51/64
3	1.51	1 1/2	1.76	1 47/64	2.01	2 1/64	2.26	2 17/64	2.52	2 33/64
4	1.36	1 23/64	1.58	1 37/64	1.81	1 13/16	2.04	2 1/32	2.27	2 17/64
5	1.23	1 7/32	1.43	1 7/16	1.64	1 41/64	1.84	1 27/32	2.05	2 3/64
6	1.09	1 3/32	1.28	1 9/32	1.46	1 29/64	1.64	1 41/64	1.83	1 53/64
7	.978	31/32	1.14	1 9/64	1.30	1 19/64	1.46	1 29/64	1.63	1 5/8
8	.876	7/8	1.02	1 1/64	1.16	1 5/32	1.31	1 5/16	1.46	1 29/64
9	.774	49/64	.903	57/64	1.03	1 1/32	1.16	1 5/32	1.29	1 9/32
10	.690	11/16	.805	51/64	.920	29/32	1.03	1 1/32	1.15	1 9/64
11	.612	39/64	.714	45/64	.816	13/16	.918	29/32	1.02	1 1/64
12	.552	35/64	.644	41/64	.736	47/64	.827	53/64	.92	59/64
13	.493	31/64	.581	37/64	.664	21/32	.747	3/4	.83	53/64

The first column gives the B & S Gage, the top line gives the number of wires wide and under each number of wires wide is given the width in decimals and the nearest smaller fraction. D=Decimal. F=Fraction.

based on the B & S round wire gage. As can be seen, the thickness is given as .051 in., .057 in., .064 in., which corresponds to Nos. 16, 15, 14, round wire and the smallest width is given as .072 in., .081 in., .091 in., and so on.

Table IV is also useful in substituting a ribbon wire for a number of round wires in parallel. For example, consider a puller coil wound with six turns of four No. 15 d.c.c. round wires in parallel, this coil being wound in layers and used in the stator winding of an induction motor. As will be noted this is a hard coil to wind, as the wires are small and will not hold together. By consulting Table IV, locate the thickness .057 corresponding to No. 15 round wire and find a width equal to four No. .057 wires, or .228 in. The nearest size from Table IV is .057 in. by .204 in. The circ.mil area of one No. 15 is 3,257 circ.mils (see Table IV, August issue, page 366). Then four No. 15 wires equal 4 × 3,257 or 13,028 circ.mils. The area of one .057-in. x .204-in. ribbon wire is 14,100 circ.mils which is a gain in copper, and also a gain in room, as the insulated diameter of one No. 15 wire is .0661 in., and the width of the four (Table I) gives .264 in. The insulated width of the ribbon (Table IV) is .16 in. or a gain of (.264 in. — .216 in.) equals .048 in., which can be used for better insulation and a smaller coil, as the winding angle of the coil ends could be decreased.

From the above it is obvious that by a careful checking of these wire tables and the proper selection of wire sizes, a considerable saving can be made in almost any coil, and not only a cheaper and quicker job made possible, but a better coil construction as well.

Table V gives the sizes of bare, soft-drawn copper strap used in coil construction or busbar work.

Table VI gives the weights, resistances, etc. for single- and double-cotton-covered magnet wire.

As already mentioned, double-cotton-covered wire has the widest range of use in the rebuilding of

Table IV—Winding Data for D.C.C. Copper Ribbon Wire

Horizontal lines separate equivalent B. & S. gage sizes for round wire.

Size				Area of Copper	
Bare		Insulated		Circ. Mils	Sq.In.
Thickness	Width	Thickness	Width		
0.0126	0.1875	0.0295	0.2015	2,964	0.00233
.0126	.2500	.0295	.2645	3,967	.00312
.0159	.1870	.0330	.2015	3,727	.00292
.0159	.2500	.0330	.2645	4,992	.00392
.016	.258	.035	.270	5,190	.00407
.020	.250	.037	.265	6,288	.00494
.020	.258	.039	.270	6,460	.00507
.025	.250	.043	.264	7,909	.006212
.025	.258	.043	.270	8,040	.00632
.025	.365	.045	.377	11,400	.00899
.0285	.120	.045	.133	4,133	.00325
.0285	.150	.045	.164	5,222	.00410
.0285	.207	.045	.221	7,291	.00573
.032	.102	.047	.112	3,880	.00304
.032	.129	.048	.132	4,980	.00391
.032	.182	.049	.193	7,140	.00560
.032	.258	.050	.270	10,200	.00804
.032	.360	.052	.377	14,600	.0015
.032	.375	.052	.387	14,999	.01178
.040	.102	.055	.112	4,760	.00374
.040	.129	.056	.139	6,130	.00482
.040	.162	.056	.173	7,810	.00614
.040	.204	.057	.215	9,950	.00782
.040	.258	.058	.270	12,700	.00998
.040	.325	.059	.337	16,100	.0127
.040	.365	.060	.377	18,200	.0143
.040	.375	.060	.389	18,798	.01476
.045	.091	.057	.101	4,660	.00366
.045	.129	.060	.140	6,840	.00537
.045	.144	.060	.155	7,700	.00605
.051	.072	.062	.083	3,990	.00314
.051	.081	.062	.092	4,580	.00360
.051	.102	.064	.113	5,940	.00467
.051	.114	.064	.125	6,720	.00528
.051	.129	.065	.140	7,690	.00604
.051	.162	.065	.173	9,840	.00773
.051	.182	.066	.194	11,100	.00875
.051	.204	.066	.216	12,600	.00987
.051	.258	.067	.271	16,100	.0126
.051	.325	.067	.338	20,400	.0160
.051	.365	.068	.378	23,000	.0181
.057	.081	.068	.092	5,200	.00408
.057	.091	.068	.102	5,920	.00465
.057	.114	.070	.125	7,590	.00596
.057	.129	.071	.140	8,680	.00682
.057	.144	.071	.155	9,770	.00767
.057	.204	.072	.216	14,100	.0111
.064	.091	.075	.102	6,730	.00529
.064	.102	.077	.113	7,630	.00599
.064	.114	.077	.125	8,610	.00676
.064	.129	.078	.140	9,830	.00772
.064	.144	.078	.155	11,000	.00868
.064	.162	.078	.173	12,500	.00983
.064	.182	.079	.194	14,100	.0111
.064	.204	.079	.216	15,900	.0125
.064	.258	.080	.271	20,300	.0160
.064	.325	.080	.338	25,800	.0203
.064	.365	.081	.378	29,100	.0228

Size				Area of Copper	
Bare		Insulated		Circ. Mils	Sq.In.
Thickness	Width	Thickness	Width		
.072	.051	.083	.062	3,990	.00314
.072	.091	.083	.102	7,660	.00602
.072	.102	.085	.114	8,670	.00681
.072	.114	.085	.125	9,770	.00767
.072	.129	.086	.140	11,100	.00875
.072	.144	.086	.155	12,500	.00983
.072	.182	.087	.194	16,000	.0126
.072	.204	.087	.216	18,000	.0142
.072	.258	.088	.271	23,000	.0180
.072	.325	.088	.338	29,100	.0229
.081	.051	.092	.062	4,580	.0036
.081	.057	.092	.068	5,200	.00408
.081	.102	.094	.114	9,840	.00773
.081	.114	.094	.126	11,100	.00870
.081	.129	.095	.141	12,600	.00991
.081	.144	.095	.156	14,200	.0111
.081	.162	.095	.175	16,000	.0126
.081	.182	.096	.195	18,000	.0142
.081	.204	.096	.217	20,400	.0160
.081	.258	.097	.272	25,900	.0204
.081	.325	.098	.339	32,800	.0258
.091	.045	.101	.057	4,660	.00366
.091	.057	.102	.068	5,920	.00465
.091	.064	.102	.075	6,730	.00529
.091	.072	.102	.083	7,660	.00602
.091	.102	.104	.115	11,100	.00875
.091	.114	.104	.126	12,500	.00984
.091	.129	.105	.141	14,300	.0112
.091	.144	.105	.156	16,000	.0126
.091	.162	.105	.175	18,000	.0142
.091	.182	.106	.195	20,400	.0160
.091	.204	.106	.217	23,000	.0180
.091	.229	.106	.242	25,900	.0203
.091	.258	.107	.272	29,206	.0229
.091	.325	.108	.339	37,000	.0290
.091	.410	.109	.424	46,900	.0268
.102	.032	.112	.047	3,880	.00304
.102	.040	.112	.055	4,760	.00374
.102	.051	.113	.064	5,940	.00467
.102	.064	.113	.077	7,630	.00599
.102	.072	.114	.085	8,670	.00681
.102	.081	.114	.094	9,840	.00773
.102	.091	.115	.104	11,100	.00875
.102	.114	.115	.127	14,100	.0111
.102	.129	.116	.142	16,100	.0126
.102	.144	.116	.157	18,000	.0142
.102	.162	.117	.176	20,400	.0160
.102	.182	.118	.196	23,000	.0180
.102	.204	.118	.218	25,800	.0203
.102	.258	.119	.273	32,800	.0258
.102	.325	.120	.340	41,500	.0326
.114	.051	.125	.064	6,720	.00528
.114	.057	.125	.070	7,590	.00596
.114	.064	.125	.077	8,610	.00676
.114	.072	.125	.085	9,770	.00767
.114	.081	.126	.094	11,100	.00870
.114	.091	.126	.104	12,500	.00984
.114	.102	.127	.115	14,100	.0111
.114	.129	.130	.144	17,700	.0139
.114	.144	.130	.159	19,900	.0156
.114	.162	.131	.178	22,500	.0176
.114	.182	.132	.198	25,400	.0199
.114	.204	.132	.220	28,600	.0224
.114	.229	.132	.245	32,200	.0253
.114	.258	.133	.275	36,400	.0286

electrical machinery. A stock of sizes from and including Nos. 18 to 5 is required, the most popular sizes being Nos. 18, 17, 16, 15, 14, 13, 12, 11, 10, and 9. Also, a stock of d.c.c. square wire in the sizes Nos. 13, 12, 11, 10 and 9 can frequently be used.

The cotton covering used on copper magnet wire is highly hygroscopic and will absorb from 5 to 8 per cent of its own weight of moisture when exposed to ordinary shop air. For this reason, it is considered good practice to bake any apparatus wound with untreated cotton-covered wire for a sufficient period to dry out the moisture and then to dip or immerse the complete apparatus while hot in a good baking varnish.

Untreated cotton covering on wire will start to turn yellow and carbonize at a temperature of 175 deg. C., and at 225 deg. C. carbonization will be complete. Therefore, the highest safe continuous temperature for baking cotton-covered wire is 95 deg. C., which is equal to 203 deg. F.

On an average, untreated, double-cotton covering between two layers of wire wound on a mandrel will puncture between 1,150 to 1,200 volts, at 60 cycles. However, this statement should not be taken to mean that a coil should be constructed with untreated or unreinforced double-cotton-covered wire when the voltage between layers or turns is above 25 volts.

As a general rule, if the voltage between turns or layers is above 25 volts, use extra insulation at points where there is any mechanical pressure exerted between adjacent wires. Field or magnet coils having a large number of turns and using No. 18 and smaller sizes of wire can be wound hit-and-miss; that is, not in layers. Armature coils for d.c. and

Table IV—Winding Data for D.C.C. Copper Ribbon Wire

(Continued from page 417)

Horizontal lines separate equivalent B. & S. sizes for round wire.

Size				Area of Copper	
Bare		Insulated		Circ. Mils	Sq.In.
Thickness	Width	Thickness	Width		
.114	.289	.133	.306	40,900	.0321
.114	.325	.134	.342	46,100	.0362
.114	.410	.135	.427	58,500	.0459
.129	.032	.139	.048	4,980	.00391
.129	.040	.139	.056	6,130	.00482
.129	.045	.140	.060	6,840	.00537
.129	.051	.140	.065	7,690	.00604
.129	.057	.140	.071	8,680	.00682
.129	.064	.140	.078	9,830	.00772
.129	.072	.140	086	11,100	.00875
.129	.081	.141	.095	12,600	.00991
.129	.091	.141	.105	14,300	.0112
.129	.102	.142	.116	16,100	.0126
.129	.114	.144	.130	17,700	.0139
.129	.162	.147	.179	25,600	.0201
.129	.182	.148	.199	28,800	.0227
.129	.204	.148	.221	32,500	.0255
.129	.229	.148	.246	36,600	.0287
.129	.258	.149	.276	41,300	.0325
.129	.325	.150	.343	52,300	.0411
.129	.410	.151	.428	66,300	.0521
.144	.045	.155	.060	7,700	.00605
.144	.057	.155	.071	9,770	.00767
.144	.064	.155	.078	11,100	.00868
.144	.072	.155	.086	12,500	.00983
.144	.081	.156	.095	14,200	.0111
.144	.091	.156	.105	16,000	.0126
.144	.102	.157	.116	18,000	.0142
.144	.114	.159	.130	19,900	.0156
.144	.182	.163	.200	32,300	.0254
.144	.204	.163	.222	36,400	.0286
.144	.258	.165	.276	46,300	.0363
.144	.289	.165	.307	51,900	.0408
.144	.325	.166	.344	58,500	.0460
.162	.040	.173	.056	7,810	.00614
.162	.051	.173	.065	9,840	.00773
.162	.064	.173	.078	12,500	.00983
.162	.081	.175	.095	16,000	.0126
.162	.091	.175	.105	18,000	.0142
.162	.102	.176	.117	20,400	.0160
.162	.114	.178	.131	22,500	.0176
.162	.129	.179	.147	25,600	.0201
.162	.204	.182	.223	41,000	.0254
.162	.258	.184	.278	52,200	.0322
.162	.325	.185	.345	66,000	.0518
.162	.365	.186	.385	74,200	.0583
.182	.032	.193	.049	7,140	.00560
.182	.051	.194	.066	11,100	.00875
.182	.064	.194	.079	14,100	.0111
.182	.072	.194	.087	16,000	.0126
.182	.081	.195	.096	18,000	.0142
.182	.091	.195	.106	20,400	.0160
.182	.102	196	.118	23,000	.0180
.182	.114	198	.132	25,400	.0199
.182	.129	.199	.148	28,800	.0227
.182	.144	.200	.163	32,300	.0254
.182	.229	.202	.248	50,700	.0398
.182	.289	.204	.310	64,600	.0507
.182	.325	.205	.346	72,900	.0573
.182	.365	.206	.386	82,200	.0645
.204	.040	.215	.057	9,950	.00782
.204	.051	.216	.066	12,600	.00987
.204	.057	.216	072	14,100	.0111
.204	.064	.216	.079	15,900	.0125
.204	.072	.216	.087	18,000	.0142
.204	.081	.217	.096	20,400	.0160
.204	.091	.217	.106	23,000	.0180
.204	.102	.218	.118	25,800	.0203
.204	.114	.220	.132	28,600	.0224
.204	.129	.221	.148	32,500	.0225
.204	.144	.222	.163	36,400	.0286
.204	.162	.223	.182	41,000	.0322
.204	.258	.227	.280	64,600	.0507
.204	.325	.228	.347	82,000	.0644
.229	.091	.242	.106	25,900	.0203
.229	.114	.245	.132	32,200	.0253
.229	.129	.246	.148	36,600	.0287
.229	.182	.249	.202	50,700	.0398
.229	.289	.252	.312	79,900	.0628
.258	.016	.270	.035	5,190	.00407
.258	.020	.270	.039	6,460	.00507
.258	.025	.270	.043	8,040	.00632
.258	.032	.270	.050	10,200	.00804
.258	.040	.270	.058	12,700	.00998
.258	.051	.271	.067	16,100	.0126
.258	.064	.271	.080	20,300	.0160
.258	.072	.271	.088	23,000	.0180
.258	.081	.272	.097	25,900	.0204
.258	091	.272	.107	29,200	.0229
.258	.102	.273	.119	32,800	.0258
.258	.114	.275	.133	36,400	.0286
.258	.129	.276	.149	41,300	.0325
.258	.144	.276	.165	46,300	.0363
.258	.162	.278	.184	52,200	.0410
.258	.204	.280	.227	64,600	.0507
.258	.365	.284	.389	116,000	.0908
.289	.114	.307	.133	40,800	.0321
.289	.144	.307	.165	51,900	.0408
.289	.182	.310	.204	64,600	.0507
.289	.229	.312	.252	79,900	.0628
.325	.040	.337	.059	16,100	.0127
.325	.051	.338	.067	20,400	.0160
.325	.064	.338	.080	25,800	.0203
.325	.072	.338	.088	29,100	.0229
.325	.081	.339	.098	32,800	.0258
.325	.091	.339	.108	37,000	.0290
.325	.102	.340	.120	41,500	.0326
.325	.114	.342	.134	46,100	.0362
.325	.129	.343	.150	52,300	.0411
.325	.144	.344	.166	58,500	.0460
.325	.162	.345	.185	66,000	.0518
.325	.182	.346	.205	72,900	.0573
.325	.204	.347	.228	82,000	.0644
.365	.025	.377	.045	11,400	.00899
.365	032	.377	.052	14,600	.0115
.365	.040	.377	.060	18,200	.0143
.365	051	.378	.068	23,000	.0181
.365	.064	.378	.081	29,100	.0228
.365	.081	.379	.099	37,000	.0290
.365	.162	.385	.186	74,200	.0583
.365	.182	.386	.206	82,200	.0645
.365	.258	.389	.284	116,000	.0908
.410	.091	.424	.109	46,900	.0368
410	.114	.427	.135	58,500	.0459
.410	.129	.428	.151	66,300	.0521

NOTE: The thickness of bare ribbon wire in this table corresponds to B & S gage round wire. Weight of copper per cubic inch = .321 lb.

Radius of Corners

Thickness	Radius
.050 in. and under	Half of thickness
.051-.105 in.	.025 in.
.106-.165 in.	.031 in.
.166-.225 in.	.041 in.
.226-.438 in.	.063 in.

a.c. machines can be wound mush, or hit-and-miss, up to and including No. 14 wire for 110- and 220-volt motors.

The heat-resisting properties of cotton-covered wires can be greatly increased by treating the coils with Liquid Bakelite. Dip armature coils, and paint each and every layer of field coils with this varnish and the Bakelite, when baked, makes the coil hard and solid and improves the heat-radiating qualities. Trip coils, blowout coils, and other small magnet coils that heat up in service and burn out can be made to stay put by the above simple method.

Field coils that are wound with round wires and run hot can be improved by rewinding them with the next smallest size square wire and treating with Bakelite. The square wire will make the over-all size of the coil smaller, reduce the resistance and the I^2R losses and improve the job in general.

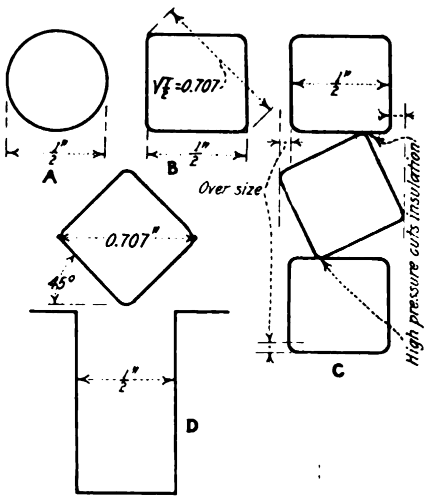


Fig. 1—This diagram shows why care must be used when winding coils with square wire.

Each side of a ½-in. square wire is equal to the diameter of a ½-in round wire, but the diagonal dimension of a ½-in. square wire is 0.707 in., as shown in *A* and *B*. *C* shows what happens when square wires are not kept flat when winding coils: the insulation is likely to be damaged and the width and depth of the coils will be increased. *D* indicates the conditions when an attempt is made to put a twisted square wire into a slot.

Table V—Winding Data for Bare (Soft Drawn) Strap Copper Wire

Horizontal lines indicate equivalent B. & S. gage sizes for round wire

Size: Thickness	Size: Width	Area Sq.In.
.010	.365	.00363
.013	.325	.00419
.016	.365	.00579
.016	.5	.00795
.020	.365	.00721
.020	.5	.00991
.020	1.25	.0249
.025	.365	.00899
.025	.5	.0124
.025	.75	.0186
.025	1.	.0249
.025	1.5	.0374
.032	.365	.0115
.032	.5	.0158
.032	.625	.0198
.032	.75	.0238
.032	.875	.0278
.032	1.	.0318
.032	1.25	.0398
.032	1.5	.0478
.032	2.	.0638
.040	.365	.0143
.040	.5	.0197
.040	.625	.0247
.040	.75	.0297
.040	.875	.0347
.040	1.25	.0497
.040	1.5	.0597
.047	.5	.0230
.047	.625	.0289
.047	.75	.0348
.047	1.	.0465
.047	1.25	.0583
.047	1.5	.0700
.047	1.75	.0818
.047	2.	.0938
.051	.365	.0181
.063	.438	.0271
.063	.5	.0306
.063	.625	.0385
.063	.75	.0464
.063	.875	0543
.063	1.	.0622
.063	1.25	.0779
.063	1.5	.0937
.063	1.75	.109
.063	2.	.120
.063	2.25	.141
.064	.258	.0160
.064	.289	.0180
.072	.365	.0257
.078	.5	.0377
.078	.625	.0475
.078	.75	.0572
.078	.875	.0670
.078	1.	.0767
.078	1.25	.0962
.078	1.5	.116
.078	2.	.155

Size: Thickness	Size: Width	Area Sq.In.
.081	.258	.0204
.091	.258	.0229
.091	.325	.0400
.094	.438	.0451
.094	.5	.0569
.094	.625	.0689
.094	.75	.0804
.094	.875	.0921
.094	1.	.116
.094	1.25	.139
.094	1.5	.163
.094	1.75	.186
.094	2.	.0604
.100	.625	.0729
.100	.75	.0854
.100	.875	.0203
.102	.204	.0203
.102	.258	.0258
.102	.289	.0289
.102	.325	.0326
.109	.438	.0469
.109	.5	.0520
.109	.625	.0656
.109	.75	.0792
.109	875	.0928
.109	1.	.1070
.109	1.25	.134
.109	1.5	.161
.109	1.75	.188
.114	.182	.0199
.114	.204	.0224
.114	.258	.0286
.114	.325	.0362
.125	.438	.0539
.125	.5	.0592
.125	.563	.0670
.125	.625	.0748
.125	.75	.0904
125	.875	.106
.125	1.	.122
.125	1.25	.153
.125	1.5	.184
.125	1.75	.215
.125	2.	.247
.129	.162	.0201
.129	.182	.0227
.129	.204	.0255
.129	.258	.0325
.141	.5	.0686
.141	.625	.0862
.141	.75	.102
.141	.875	.120
.144	Sq.	.0199
.144	.182	.0254
.144	.204	.0286
.144	.258	.0363
.156	.438	.0675
.156	.5	.0761
.156	.625	.0956

Size: Thickness	Size: Width	Area Sq.In.
.156	.75	.114
.156	.875	.133
.156	1.	.153
.156	1.25	.192
.156	1.5	.231
.156	1.75	.270
.156	2.25	.348
.162	Sq.	.0254
.162	.204	.0322
.162	.289	.0460
.162	.325	.0518
.162	.365	.0583
.182	Sq.	.0312
.182	.258	.0451
.188	.5	.0921
.188	.625	.116
.188	.75	.138
.188	.875	.161
.188	1.	.185
.188	1.25	.232
.188	1.5	.279
.188	2.	.373
.188	2.5	.467
.204	Sq.	.0397
.204	.258	.0507
.219	.365	.0780
.219	.438	.0940
.219	.5	.108
.219	.625	.135
.219	.75	.161
.219	1.	.216
.229	Sq.	.0490
.229	.289	.0628
.229	.365	.0802
.250	.5	.122
.250	.875	.211
.250	1.	.242
.250	1.25	.305
.250	1.5	.367
.250	2.	.492
.250	2.5	.617
.250	3.	.742
.250	4.	.992
.258	Sq.	.0632
.258	.365	.0908
.289	Sq.	.0801
.313	.5	.153
.313	1.	.305
.313	1.25	.384
.313	1.5	.462
.313	2.	.618
.375	1.	.367
.375	1.25	.461
.375	1.5	.555
.375	2.	.742
.375	2.5	.930
.375	3.	1.12
.375	4.	1.49

Radius of corners same as for ribbon wire—See Table IV.

Single-Cotton and Enamel-Covered Wires. — Single cotton and enamel is the next important covering for wires and is the enameled wire already mentioned with one reinforcing layer of cotton.

This wire finds quite a large range of use for the running or main windings of single-phase motors and is safe to use for any mush-wound coil in an a.c. or d.c. field, rotor or stator. In fact, any repair shop would be taking a step in the right direction to replace the double-cotton covering on bare wire used in mush-wound coils with this single-cotton and enamel-covered wire. The stock sizes should be Nos. 20, 19, 18, 17, 16, 15, and 14.

This wire has all the good features of the enameled wire, with the advantage of the cotton covering acting as a cushion and protection. Also, when the complete apparatus is dipped, the added varnish film improves the insulating properties.

The results of a test between double-cotton-covered wire and single-cotton and enameled wire will indicate the benefits in using the latter for mush-coil jobs. The test consisted of winding on elayer on a ¾-in. metal mandrel and testing between layers.

The results showed that one layer of double-cotton-covered wire will stand, on an average, 570 volts to ground and that single-cotton and enameled wire in one layer will stand on an average 770 volts to ground. The second test showed that double-cotton between layers will stand 1,100 volts and single-cotton and enamel, 1,900 volts. These tests were made with a 5-kw. transformer, 60 cycles, 110 volts on the primary line.

Table VII gives the weights, etc.,

Table VI—Dimensions, Weight and Resistance of Single- and Double-Cotton Covered Round Magnet Wire

B. & S. Gage	Diameter Bare Wire in Inches	Feet per Pound		Pounds per 1,000 Feet		Ohms per Pound	
		Single c.c.	Double c.c.	Single c.c.	Double c.c.	Single c.c.	Double c.c.
8	0.1280	19.8	19.6	50.6	51.0	.0124	.0123
9	.1144	24.9	24.6	40.2	40.6	.0197	.0194
10	.1018	31.4	30.9	31.8	32.4	.0313	.0308
11	.0907	39.5	38.8	25.3	25.8	.0496	.0487
12	.0808	49.8	48.9	20.1	20.4	.0790	.0775
13	.0719	62.6	61.5	16.0	16.3	.125	.123
14	.0641	78.8	77.3	12.7	12.9	.199	.195
15	.0571	99.4	97.3	10.1	10.3	.316	.309
16	.0508	125.	122.	8.0	8.20	.501	.489
17	.0453	157.	151.	6.37	6.62	.795	.764
18	.0403	198.	192.	5.05	5.21	1.26	1.22
19	.0359	248.	240.	4.03	4.17	1.99	1.93
20	.0320	311.	298.	3.22	3.36	3.16	3.02
21	.0285	390.	373.	2.56	2.68	4.98	4.76
22	.0253	489.	464.	2.04	2.16	7.89	7.48
23	.0226	611.	575.	1.64	1.74	12.4	11.7
24	.0201	765.	711.	1.31	1.41	19.6	18.2
25	.0179	955.	878.	1.05	1.14	30.8	28.4
26	.0159	1,190	1,080	.840	.925	48.5	44.0
27	.0142	1,490.	1,330.	.671	.752	76.5	68.3
28	.0126	1,850.	1,630.	.540	.613	120.	106.
29	.0113	2,300.	1,990.	.435	.502	188.	163.
30	.0100	2,860.	2,420.	.350	.413	294.	249.
31	.0089	3,530.	2,820.	.283	.354	459.	366.
32	.0079	4,370.	3,500.	.229	.286	715.	573.
33	.0071	5,380.	4,160.	.186	.240	1,110.	860.
34	.0063	6,520.	4,920.	.154	.203	1,700.	1,280.
35	.0056	8,120.	5,760.	.123	.174	2,670.	1,890.
36	.0050	9,940.	6,660.	.101	.150	4,110.	2,760.
37	.0044	12,100.	7,600.	.0826	.132	6,320.	3,970.
38	.0040	14,700.	8,450.	.0680	.118	9,680.	5,560.

"Single c.c." = single-cotton covering; "Double c.c." = double-cotton covering.

of single- and double-cotton-covered and enameled magnet wire. By comparing columns 7 and 8 of Table IV (August issue, page 366) it will be noticed that the insulated size of single-cotton and enamel-covered wire is smaller than the corresponding B & S gage size of double-cotton-covered wire, thus resulting in a better space factor and easier winding job.

Double-Cotton-Covered and Enameled Wire.—Next in line of importance as a wire insulation, is the double-cotton and enamel covering. This wire requires more room than either the double-cotton or single-cotton and enameled wire, but has a higher breakdown voltage, the single layer standing on an average 1,200 volts and a voltage between layers of 4,000 volts. This is a good wire to use for jobs where the voltage between turns or layers is high, as in induction regulators and transformers, but for general use, the room required is too great and its cost is higher.

It might be of interest to note that two layers of double-cotton and enameled, gum-treated wire have stood as high as 15,000 volts between layers on a mandrel test.

Another article will deal with special insulation for limited space and high temperature conditions.

Table VII—Dimensions, Weight and Resistance of Single- and Double-Cotton Covered Enameled Magnet Wire

B. & S. Gage	Diameter Bare Wire in Inches	Feet per Pound		Pounds per 1,000 Feet		Ohms per Pound	
		S.C.-En.	D.C.-En.	S.C.-En.	D.C.-En.	S.C.-En.	D.C.-En.
8	.1280	19.7	19.4	50.7	51.5	.0124	.0122
9	.1144	24.7	24.2	40.5	41.3	.0195	.0191
10	.1018	31.0	30.4	32.3	32.9	.0309	.0303
11	.0907	39.2	38.2	25.5	26.2	.0492	.0480
12	.0808	49.3	48.0	20.3	20.8	.0783	.0761
13	.0719	62.0	60.3	16.1	16.6	.124	.121
14	.0641	78.1	75.8	12.8	13.2	.197	.191
15	.0571	98.3	95.2	10.2	10.5	.312	.302
16	.0508	124.	118.	8.06	8.48	.497	.473
17	.0453	156.	150.	6.41	6.67	.789	.759
18	.0403	194.	187.	5.15	5.35	1.24	1.19
19	.0359	245.	234.	4.08	4.27	1.97	1.88
20	.0320	307.	291.	3.26	3.44	3.12	2.95
21	.0285	385.	362.	2.60	2.76	4.91	4.62
22	.0253	481.	449.	2.08	2.23	7.76	7.25
23	.0226	601.	555.	1.66	1.80	12.2	11.3
24	.0201	750.	684.	1.33	1.46	19.2	17.5
25	.0179	936.	842.	1.07	1.19	30.2	27.2
26	.0159	1,170.	1,040.	.855	.961	47.7	42.3
27	.0142	1,450.	1,270.	.690	.788	74.5	65.2
28	.0126	1,810.	1,550.	.552	.645	117.	100.
29	.0113	2,240.	1,880.	.446	.532	183.	154.
30	.0100	2,780.	2,280.	.360	.438	286.	235.
31	.0089	3,440.	2,720.	.291	.368	447.	353.
32	.0079	4,240.	3,240.	.236	.309	695.	531.
33	.0071	5,200.	3,820.	.192	.262	1,070.	789.
34	.0063	6,380.	4,460.	.157	.224	1,660.	1,160.
35	.0056	7,810.	5,140.	.128	.195	2,560.	1,690.
36	.0050	9,540.	5,850.	.105	.171	3,950.	2,420.
37	.0044	11,600.	6,530.	.0862	.153	6,060.	3,410.
38	.0040	14,000.	7,020.	.0715	.143	9,220.	4,620.

S.C.-En. = single-cotton covering and enamel; D.C.-En. = double-cotton covering and enamel.

Lubrication of Cranes and Hoists

(Continued from page 408)

and the other on the trolley. Pressure up to 30 lb. per sq.in. is applied at the bearings. By means of rubber hose and pipe fittings, the grease is distributed to all bearings except those on the motor.

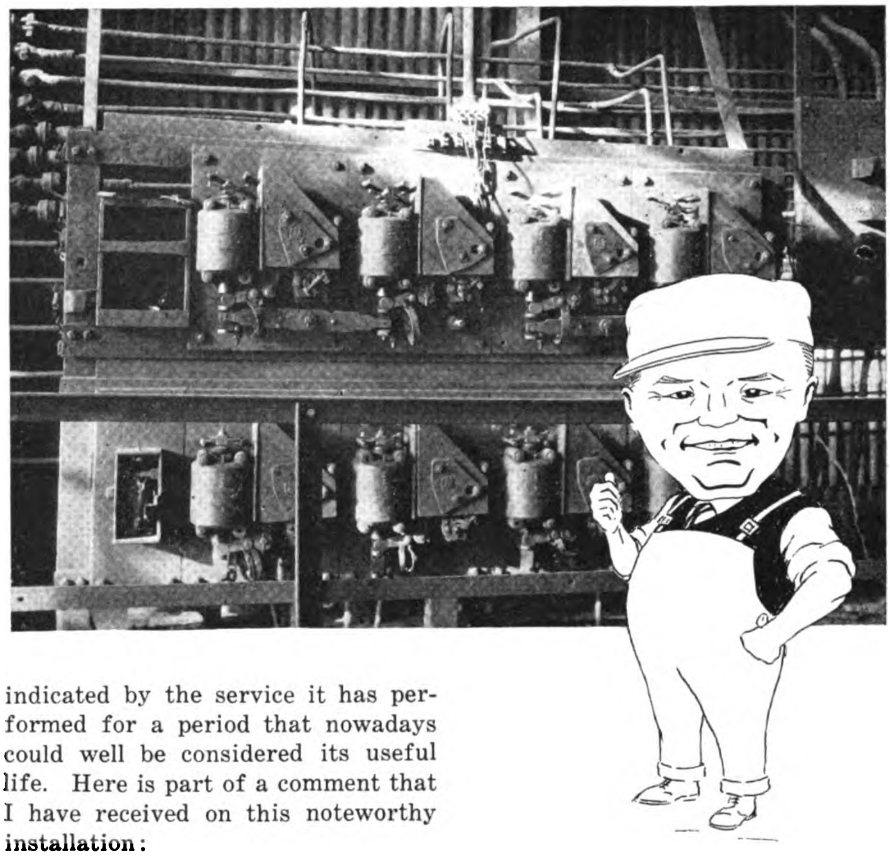
Grease is supplied weekly to the crane operator by the Maintenance Department, so that none is left around the crane to be wasted or become dirty. The operator screws up on the gun every day. A saving of approximately $250 per year per crane has been effected by this means, it is estimated by the user. This is the result of less grease consumption and the fact that the crane and operator are subject to less lost time than when the old, hand grease cups were in use. Also, fewer burned-out bearings result from new operators not finding the location of the grease cups.

The gears on the trolley are frequently enclosed in a gear case and run in oil, as shown in one of the accompanying illustrations. For such installations the manufacturer of the crane usually recommends one of the standard gear case oils. One manufacturer recommends that for winter service on outside cranes this oil be thinned by the addition of 50 per cent of machine oil. Manufacturers of lubricants will supply oils for such outside service in winter

(Please turn to page 435)

Today We Think But Next Year We Know

when pushing into new ground and spending money on today's conception of the return it will be capable of earning.



I BELIEVE that most of us have a pictorial memory: that is to say, we hold in our mind impressions of things as we see them most frequently. For this reason stages of progress in our work or improvements in the methods we employ are compared as advances from week to week or from year to year. Because of this we sometimes need to go back into the musty pages of history in order to get a true perspective of just what we have accomplished as individuals, and as a nation, over a period of a half century or so. This is true of advancement along any line, whether it be art, music, warfare or what not, but particularly is it true of electrical engineering which, in its practical application, does not cover much of a period of time as civilization measures it.

All of this leads up to the reason for calling your attention to the accompanying photo taken in the Pueblo plant of the Colorado Fuel and Iron Company. It shows what one type of motor control for the tables of a 36-in. blooming mill looked like just 16 years ago, in the early days of electric drive in steel mills.

Today the control that is made in the same factory does not look much like this, but the knowledge and confidence that was wrapped up in it is indicated by the service it has performed for a period that nowadays could well be considered its useful life. Here is part of a comment that I have received on this noteworthy installation:

If you are acquainted with steel mill practice, you will understand that the roll tables, which are operated through this old controller, handle the ingot as it passes back and forth between the rolls while the ingot is being reduced to a bloom of the desired size. The roll tables are reversed several times during the rolling of the ingot to a bloom, the actual number depending on the size of the ingot and the skill of the operator in charge.

It is estimated that nearly one and three-quarter million ingots have been rolled between May 1, 1910 and the present time. At this figure the total number of reversals of the motors on these roll tables handled through this control board have exceeded 31,000,000. Quite evidently old age has not crippled this old-timer, for the failure of the controller would cause a mill delay and trouble of this nature is practically unknown here.

And so it goes. Today we cudgel our brains for ideas to improve methods and save time and money in a particular operation, sometimes stumbling onto ideas that give immediate results, but more often it requires some years to determine the exact value of the effort. Right here I might drop this suggestion—when the cost of a job is being considered and an appropriation is asked for, think first about the value of the results and then pick and choose with equal care the equipment that will measure up to the best ideas you now have.

In years to come the first cost will look small beside the saving and improvement you will be able to show. In too many cases a good idea has been spoiled by the handicaps of cutting the pattern to suit the cloth, which means spending $500 on a $10,000 idea. If you are convinced that the idea will produce a 20 per cent return annually and thus pay for its execution in not more than 5 years, then get that return by installing equipment that measures up to the degree of confidence you have in your ideas and yourself. Anything short of this is expensive to your company and unfair to yourself.

Practical Pete

INDUSTRIAL ENGINEER
Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories
G. A. VAN BRUNT, *Managing Editor*

Artificial Light of Daylight Quality Has Many Uses in Industry

FOR ages artificial light sources were so feeble and inefficient that mankind had to be satisfied with the quality of the light without attempting to alter it. The advances in the efficiency of light production during the past score of years have made it possible not only to distribute the light where desired, but also to alter it to the desired quality or color value. In general, daylight quality is the most suitable for vision. Our eyes evolved under it, and it is not surprising that our eyes are best adapted to it. When color discrimination is important it cannot be denied that daylight quality is best. Color is in the light and not in the object. A colored surface appears colored because it has the property of absorbing radiations of certain wavelengths and reflecting (or transmitting) the remainder. Thus, if we take visible radiations of certain wavelengths away from white light the remaining light is colored, the exact color depending upon the wavelengths remaining.

Artificial daylight is now available for accurate color discrimination and tungsten "daylight" lamps provide light of approximately daylight quality for more general use. We depend upon color vision much more than we realize and, in the industries, light that approaches daylight quality is helpful in most places, although this is not generally recognized. Experiments also indicate that approximate daylight quality is somewhat "easier on the eyes" than is ordinary artificial light. There is an increasing sentiment toward the use of these lamps for inspection work, owing to the results now being obtained in many classes of inspection even where color is a seemingly minor factor. Tungsten "daylight" lamps for general lighting, and accurate, color-discrimination units for special lighting, are profitable tools in many places.

Is Your Material-Handling Equipment Getting Proper Lubrication?

ALTHOUGH operation routine usually provides a regular schedule for the lubrication of production machinery, some types of equipment found in many industrial plants are often neglected. Of this class, material-handling equipment probably suffers the most. In many cases such equipment is used irregularly, and generally at a low bearing-surface speed. Cranes and conveyors, particularly, are often located in almost inaccessible places where oiling is a hazardous operation, and accidents are likely to be serious. In such cases the oiler can hardly be blamed for occasionally "missing" some of the least accessible bearings.

Also, there is a general belief that bearings which operate at low speed, such as on conveyors, do not need much attention and as a result they get but little. Here, the effects of neglecting lubrication, such as worn or frozen bearings, will probably be slow in appearing, but they are almost inevitable, especially if the equipment is operating in dusty or dirty surroundings. Hot conveyor bearings, which were due to neglect of lubrication, have been known to start fires and cause explosions in elevators and mills which generate an explosive dust.

There are numerous methods of making the lubrication of such equipment not only easier, and so more likely to be taken care of regularly, but also less hazardous to the oiler. Some of these methods depend upon the design of the bearings; others depend upon the method of applying the lubricant which, of course, should in all cases be of the proper consistency for the bearing and the operating conditions.

The article entitled "Problems in the Lubrication of Hoists and Traveling Cranes," which begins on page 406 of this issue, may serve to show how you can obtain better service from your material-handling equipment at lower operating and maintenance costs, and reduce the accident hazards to the men who have to lubricate it.

Reducing Amount of Supplies in Stock Will Lower Operating Costs

MUCH of what has been accomplished in the way of eliminating waste by reducing the number and variety of stock sizes of various commodities, is a matter of common knowledge. This important work is being carried on under the joint auspices of the Division of Simplified Practice of the Department of Commerce, and the National Committee on Metals Utilization, under the direction of Secretary Hoover, in co-operation with trade associations, manufacturers and others connected with the industry in question. Up to the present time between 50 and 60 items have been studied and recommendations prepared covering them.

The manufacturers of carbon brushes and brush shunts have long realized that they are spreading their production and investment over a range of sizes that are legion in number. The distributors of brushes have had to carry large stocks so as to meet every possible demand, when the bulk of normal requirements could be adequately satisfied with fewer variations in sizes and dimensions. The consequent confusion of choice has affected the manufacturers of brush-holders, which are an item of supreme importance in the design of motors and generators destined for a myriad number of uses. Whenever a new size of brush has appeared on the market the manufacturers of brush-holders have had to increase the variety of their product, while the producers of brushes have found themselves similarly influenced by the growing list of holder sizes. The

user of such equipment has found himself in the center of a vicious circle, sharing its cost and disadvantages.

At the request of The Electric Power Club, the Division of Simplified Practice invited representative manufacturers, distributors and users of carbon brushes to meet in Washington a few weeks ago and discuss the tentative recommendations covering carbon brushes and brush shunts, which had been proposed by this organization. Except for a few minor changes, these recommendations were approved by the conference as originally submitted, to become effective November 1.

Marked savings have been made possible for both manufacturers and users by the application of the principles of simplified practice to a number of commodities, and there is every reason to feel that these principles can be applied with equal success to the manufacture and use of carbon brushes and brush shunts. A reduction in the number of sizes and types should lower manufacturing costs as well as operating and maintenance charges by reducing the capital tied up in stock.

Any movement which will accomplish these very desirable ends is worthy of strong support on the part of every operating executive.

Poor Work and Shirked Responsibility Cannot Be Covered Up Forever

ABOUT 3,000 years ago a workman in a tomb of one of the ancient rulers of Egypt brushed some shavings and débris of his task in an out-of-the-way corner, probably saying to himself, "What's the difference; it will never be seen." Recent explorers in these ancient tombs brought to light the fact that this man was remiss in his responsibilities.

Many times in maintenance activities, a workman, particularly if he is on the job alone, is tempted to let something go partially finished when he feels that there is little likelihood that the evidence of his neglect will ever be discovered in such a way, or soon enough, for the responsibility to be placed upon him. A scratch or burr on a shaft inside of a bearing does not show, but sooner or later when that bearing begins to run hot, the imperfect workmanship will be discovered, and in all likelihood this will happen within a few days or hours, instead of centuries, as was the case with this Egyptian workman.

Nor are the opportunity and temptation to be careless confined to those in the ranks. Every executive in an organization, from the President to the youngest foreman, has plenty of chances to slight his work. Probably only he knows how often he fails to handle a job to the full measure of his ability. Nevertheless, there is certain to be a day of reckoning: carelessness and failure to realize the importance of doing one's best at all times, are sure to be recognized eventually. and they exact a penalty that must be paid.

When the time for promotion comes along the slipshod, careless fellow, who takes the path of least resistance, is pretty likely to be passed by.

Thinking Up Good Ideas Is the Job of Everyone on the Force

ONE of the first essentials of a truly successful organization is that the subordinates in it display considerable initiative, not only in the execution of their own work, but in the planning of new work that is to be done by the organization. Developing initiative in his subordinates should be the self-imposed task of every good executive.

A large, commercial electric repair shop in Detroit, is an example of how this has been successfully worked out. This shop is operated by a force of about 50 men, each one of whom is an enthusiastic believer in what the firm can do. The shop has had a very successful and prosperous career, most of which is due to the personnel.

Many new ideas have been developed in this shop. For example, it was found that stripping the insulation by hand from the ends of armature coils was too expensive to be consistent with the cost of making the coils. One of the repairmen got the idea that the insulation could be removed by rotary wire brushes, and the result of this good idea was a motor-driven insulation stripper.

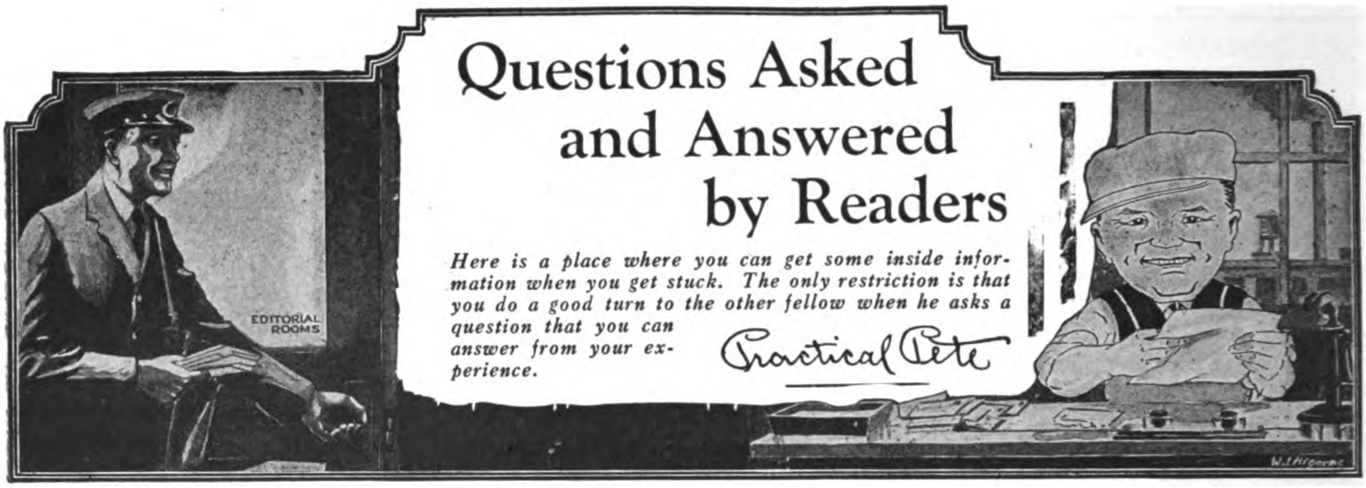
A good deal of shaft-pressing was done in the shop; so a 150-ton hydraulic jack was purchased. An ingenious method of mounting this jack was developed, and in addition it was arranged so that it could be operated by compressed air in setting up the work. This saves much time and makes more accurate adjustment possible with less blocking up. The mounting and the arrangement for using compressed air were planned by the shopmen.

One of the foremen designed a dynamometer that uses a generator arranged so that both the armature and the stator are free to revolve. This device greatly simplifies load testing of motors.

A winder thought of a unique way to make a stand on which to wind fractional horsepower motors—a stand that would securely hold the stator in any desired position. Such a device has shortened the winding time considerably.

The men in this shop are simply bubbling over with ideas, and their ideas are worth while. In talking with some of them the reason for such an oversupply of initiative was discovered: thinking of ideas and making them practical is encouraged by the management. The men know that they will be paid for acceptable ideas. As a result of the management's attitude new ways and methods of handling the work are everywhere in evidence.

All of which brings us back to the fact that no executive has a corner on all of the worth-while ideas. In fact, there is a fair chance that he has run out of ideas and is constantly hoping that some of his subordinates will bring forth something worth while. The one-man organization is on the wane—the man at the head of it wears out too rapidly. Think—and then develop the ideas that are the result of your thinking.



Who Can Answer These?

What Size of Belt Is Required for This Drive?—A 15-hp., 1,750-r.p.m. motor is used to drive a punch press. The pulley on the motor is 6 in. in diameter and the driven pulley is 40 in. in diameter, the distance between centers of the motor and press pulleys being 15 ft. I wish readers would give me some information regarding the adaptability of leather belts to this drive. Specifically what width of leather should be used to give the best results? Should this belt be single or double-ply? Would you advise the use of some other type of belt and if so, what kind and why?
Rockford, Ill. R. W. A.

* * * *

Thawing Frozen Water Pipes.—I should like to obtain data for building a transformer drawing about 600 amp. on the secondary side, which is to be used for thawing out frozen water pipes. The transformer is to be used on a 115-volt circuit and I shall be grateful if some reader will let me know the size of core to use, the size of wire, and the number of turns on the secondary and primary windings. What should the secondary voltage be, in order to give the best results for my purposes?
Duluth, Minn. F. G. G.

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What Is Wrong With This Exciter?—We have a $7\frac{1}{2}$-kw., 125-volt, 60-amp., 1,200-r.p.m. exciter that has always given us considerable trouble. It sparks badly, thereby shortening the life of the brushes and of the commutator. Flats appear on opposite sides of the commutator and the individual bars are badly burned. Channels are burned lengthwise in the center of the bars to a depth of about $\frac{1}{16}$ in. This machine has four poles, the commutator having 49 bars on the original armature, while the spare armature has 97 bars and 49 coils. Each time we turn the commutator we undercut the mica and test the armature on a transformer or growler. When an armature is replaced in the machine we fit a new set of brushes as supplied by the maker of the machine, and start it with a normal load of 45 amp. It will run well for a day or two with scarcely any sparking. Then it begins to spark and the commutator blackens and heats up. I wish other readers who have had similar experience would tell me how they corrected the trouble.
New Philadelphia, Ohio. R. F. P.

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Trouble from Cable Overheating—In connecting up a turbo-generator rated at 480 volts, three phase, 60 cycles, 3,000 amp., I used five 1,000,000-circ.mil, rubber-covered cables in parallel. According to the wire table each cable should carry 650 amp.; therefore, the six cables in parallel should carry a total of 3,900 amp. The total of 18 cables for the three phases run in six conduits, each conduit carrying three cables, one from each phase. With this arrangement the cables heated and I found it necessary to add a seventh cable to each phase. This should give a total carrying capacity of 4,550 amp. which is 50 per cent more than the rating of the turbo-generator, 3,000 amp. With the seven cables operating in parallel on each phase there is no heating and the cables carry satisfactorily an average load of 3,000 amp. with peaks running somewhat over 3,500 amp. Can any reader suggest causes why the first installation of cables should overheat? Could it be due to inductive effects? If so, how could I go about correcting this trouble?
Bellingham, Wash. E. M. D.

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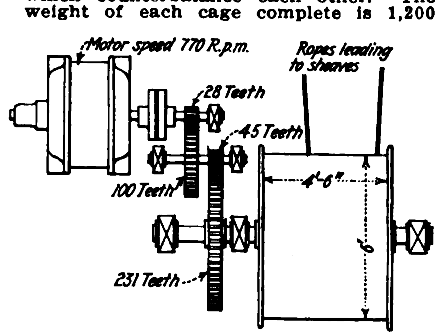
Difference Between Star and Delta-Connected Motor Windings. — Can some reader tell me if there is any difference in the starting current, torque, power factor, and efficiency of a star-connected motor winding as compared to a delta-connected winding. In each case the motors under consideration are of the same make, horsepower, and number of coils. Why are some motors star-connected while others are delta-connected? Does either form of connection have advantages over the other? I shall greatly appreciate any information that readers may give me on this subject.
Lethbridge, Alberta, Can. W. T.

* * * *

Size of Motor Required for Hoist.—Will some reader kindly show me how to calculate the size of motor required for this coal hoist. A three-phase, 40-cycle, 770-r.p.m. motor is to drive a winding drum through two sets of reduction gears, as shown in the diagram. Cables from the winding drum support two cages which counterbalance each other. The weight of each cage complete is 1,200



lb. The cages are to be used for raising trucks of coal. Empty trucks weigh 550 lb. and a truck will carry 850 lb. of coal per load. Each trip of the hoist will carry up one loaded truck and lower one empty truck simultaneously. The distance through which the load must be hoisted is 270 ft. I should also like to know what the power consumption would be when raising 15 tons of coal (about 36 loads) per hour. I shall appreciate it if some reader will show me how to work out the torque and power diagrams.
South Shields, Eng. G. B.

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How Many Men Are Required for Maintenance in This Plant?—I wish readers would tell me how many men we should have for carrying on the electrical maintenance and repair work in our power house. This plant is a central station isolated from other companies and is self-dependent. It has five generating units: one 20,000 kva., two 6,000 kva., one 3,500 kva., and one 3,200 kva. There are four exciters, two rotary converters, and two 550-volt commercial d.c. generators. The plant also contains three banks of bus tie transformers as well as three 33,000-volt transformers. There are 121 motors ranging in size from $\frac{1}{16}$ to 200 hp. at 220 and 2,300 volts, and also a 44-panel switchboard with auxiliary switchboards as needed. This plant has automatic control and interlocking systems and is modern in every respect. Some of the apparatus is three years old. We expect to handle all repair work such as winding and testing, as well as any new installation work that may be required. I am chiefly interested in the number of men required and the particular work that should be assigned to each. Your opinions will be very helpful.
Aurora, Ill. E. J. M.

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Answers Received To Questions Asked

Best Way to Install Ball Bearings in Line-shaft Hangers.—We are going to replace the split, babbitted, shaft-hanger bearings on a $2\frac{7}{16}$-in., 72-ft. shaft with new ball bearings. The same drop hangers are to be used. Two solid pulleys are used; the remainder are split, either wood or steel. The shafts are connected with keyed flange couplings. What is the best way to go about making the change? Would it be best to let the shaft down to the floor, or work overhead? What is the easiest way of getting the flanges off and on again? Would it be better to replace them with compression couplings?
Syracuse, N. Y. H. L. G.

The question asked by H.L.G. on whether or not to lower the shaft to the floor when installing ball-bearing hanger boxes depends upon whether the couplings can be removed without undue trouble and what machinery or other equipment is in the way below.

Keyed flange couplings are often put on in such a manner that the man who does the work says, "Well, I hope I don't have to take them off." With the shaft badly battered up and the key sledged in an inch after it should have been left alone, it is a heartbreaking job to remove the couplings. In such a case, drilling out the key or taking the assembled length to a neighboring shop, when the plant does not have such equipment, to have the couplings removed in a hydraulic press, is about the only way to strip the line.

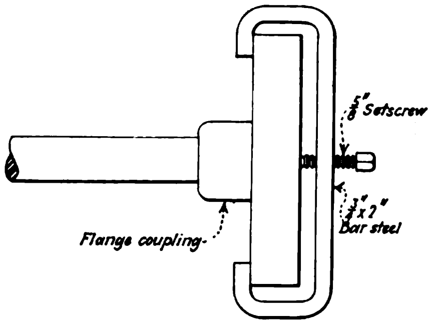
On the other hand, couplings put on intelligently present no great difficulty in their removal. With such couplings more trouble is caused by rust than any

other gripping factor. It is suggested that the joints be liberally supplied with one of the "penetrating oils" that are such good looseners of rusty parts; this should be done nightly for several days before the job is attempted. The couplings should then be easily removed.

All couplings should be provided with two tapped holes for removing, but if there are none, a puller can be used instead. A simple puller which is light enough to be handled easily may be made for the job, if no other is available, from a piece of ¾x2-in., or heavier, steel of the form shown in one of the accompanying illustrations and to fit the style of coupling used. In using a puller, if the coupling does not move with moderate screw pressure, it can be started by driving on the hub at the back with a bar between the hammer and the hub to prevent bruising the coupling. Usually, only one blow is required to break the grip and then the piece comes off readily enough.

Changing couplings and bearings is something like painting, in that it is easy to do in an empty building but when it has to be done in a building that has machinery or other equipment and stock underneath, it is attended with considerable difficulty. When such is the case the writer prefers to make the bearing change in the air. Also, if the shaft is kept overhead by the proper type of retainers there is not the risk of a length of shaft getting away and plunging into a machine or valuable stock, as is the case when the shaft is taken down. Likewise, the job of lowering and raising again lengths of shaft, often weighing 600 lb., besides pulleys, is avoided. Ordinarily few belts have to be taken off. Some pulleys must be removed, of course, but by working from both ends of the shaft it is seldom necessary to take off all of them.

To do the work in the air, two or more slings are required. These, and the puller mentioned before, are simple pieces for a blacksmith to make. Their cost is trifling, as compared with the saving effected, and they can be turned to other uses when the job is done. They have to be prepared in advance;



A simple and easily constructed coupling puller which is light enough for use on overhead work.

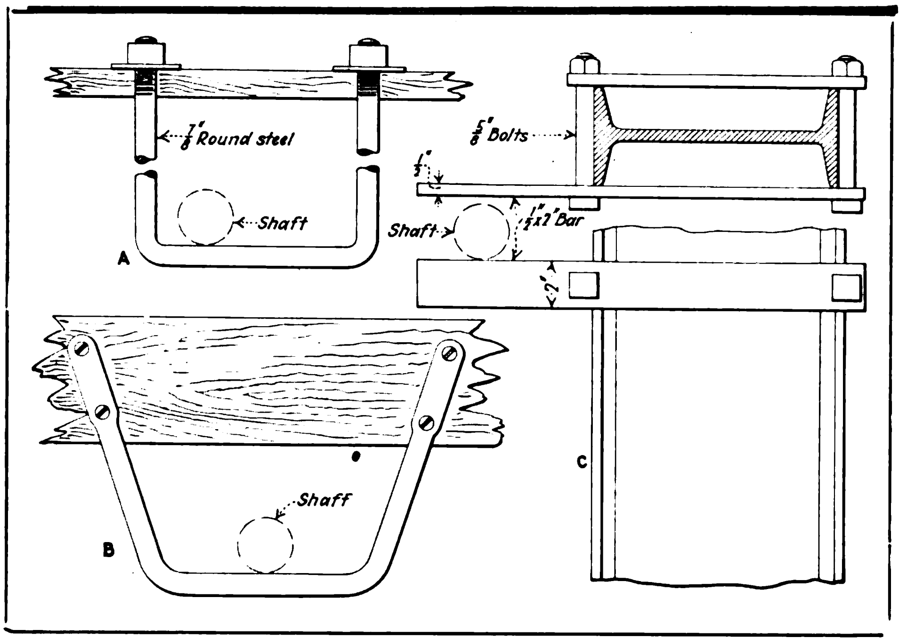
the location must be measured up and the slings made to suit.

Three types of slings are shown in the accompanying group illustration. Slings of the type designated as *A* are used where holes can be bored through the floor above. When this loop-shaped sling is thrust up through the floor, a steel plate is slipped over each end before the nut is put on. At *B* is shown a sling that is meant to be lagscrewed to the side of overhead beams. Where columns of structural steel or wood are close to the line of shafting, the type of clamp shown at *C* supplies an easy method of supporting a shaft. The type of sling required depends upon the construction of the building. If the building is of steel and concrete construction, it will be necessary to provide means for attaching the slings.

With drop-bottom hangers, the slings must be erected so that their horizontal run is about 6 in. below the end of the hanger after the cap is taken off. Some

Three types of slings for supporting shafting while changing to ball-bearing hanger boxes.

The type of sling shown at *A* is used where it is possible to bore holes through the floor above. Sling *B* is lagscrewed to the ceiling beams. Sling *C* is clamped to steel columns or wood posts. These slings are made to measure and erected before the shaft is loosened. Frequently the construction of the building requires some modification of these slings.



designs of ball bearings will require more drop, and others, less. The simplest method of holding up the weight of the shaft while the bottom of the hanger is being taken off is to have a man below holding it up with a rope passed over some member above the shaft level. Sometimes it is necessary to erect a sheave wheel or screw a hook into a beam or some other part of the structure for the rope to pass over. Often the design of the hanger is such that a rope can be passed over it.

Horses or ladders have to be used and with them it is often possible for helpers to take the weight of the shaft while the mechanic removes the hanger cap. The slings have been put up before the caps are taken off, of course.

For heavier shafts, the writer has found that the portable floor crane enables only two men to proceed very fast with a shaft job. If the crane is not heavy enough of itself, weights are added so that its chain (or cable) can be carried upward and over a sheave erected above the shaft; the winch on the crane is then used for lowering and raising the shaft. For work in rooms with high ceilings the length of the chain is increased by tying a rope on the end of it. Some buildings will permit the use of chain hoists, although they are usually useless because of low headroom.

The writer prefers the compression coupling to the usual keyed flange couplings, provided they are watched for the first few months and taken up, as they should be, after settling to the work.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

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Winding Rectangular Wire on Edge.—I would like some suggestions from readers on how to wind coils, using rectangular wire or ribbon. These coils have to be wound with the copper on edge. My particular problem is the mechanical operation of winding the thin copper strips on edge without using too elaborate a machine. To be specific, I desire to wind both a round and an approximately square coil, using 1/16-in. by ⅜-in. copper ribbon. The diameter of the core of this coil should be 1 in. and in the case of the square coil, the side should be 1 in. I also desire to make up a coil around a 1-in. core using strip copper 0.01 in. by 1 in.

Bloomington, Ill. A. S.

In reference to the question of A. S., I have never had any actual experience with wire coils of the size he has in mind, but the following method has been satisfactory for winding large, oblong coils of copper strip ⅛ in. thick by 1 in. wide.

The copper strip is clamped securely to the faceplate of a lathe and formed about an arbor. A hand tool of convenient size made of cold-rolled steel of suitable thickness and width is used for guiding the turns of copper strip. This guiding tool has a slot of sufficient size to slip over the strip, while the end is made in the shape of a hook to fit tightly against the arbor. When the lathe is started slowly, the tool is held firmly in the hand and the copper is fed through against tension. The thickness of the slot side next to the faceplate may be about 1/16 in. as the coil can be easily pressed together after finishing.

The above method will, of course, serve only for round coils. However,

square coils can be wound by mounting a similar guide in the tool post of the lathe, with provision for allowing the guide to rock up and down slightly and thus follow the slight up and down motion of the copper strip. The coil can be wound without much trouble if the copper is held firmly upright while making the turn. There will be a slight widening of the strip on the inner edge but this will not be enough to be objectionable.

This method of winding round and square coils is very simple and if it works satisfactorily, as it probably will, A. S. will have a means of doing the job without an elaborate machine, and at a very low cost. J. M. WALSH.

Ass't Chief Engineer,
Gurney Elevator Co.,
New York, N. Y.

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What is the Function of a Reactive Volt-Ampere Indicator?—We recently ordered from a meter manufacturer a three-phase, switchboard-type wattmeter. When the meter arrived at the plant it was marked, reactive volt-ampere indicator, instead of wattmeter. I wish some of the readers of this column would explain the difference between these two meters and tell me the application and use of the reactive volt-ampere meter. Any details regarding the use of this meter will be very helpful.
Detroit, Mich. R. J. B.

R.J.B. states that a reactive volt-ampere meter had been shipped him in error when he had ordered a wattmeter. He asks information regarding the use of this meter.

The reactive volt-ampere meter is used to determine the power factor of an alternating-current circuit. This meter measures the so-called idle or reactive component, which is at an angle of 90 deg. to the useful, or power component, which is known as the watt component.

RATIO OF REACTIVE KVA. TO KW.	POWER FACTOR
0.00	1.00
0.33	.95
0.48	.90
0.62	.85
0.75	.80
0.88	.75
1.02	.70
1.33	.60
1.73	.50

R.J.B. may be interested in knowing what use is made of the reactive volt-ampere meter in connection with measurement of power factor. The accompanying table shows two readings, the left-hand column being the ratio of the reading of the reactive meter to the reading of the wattmeter. Corresponding to the various ratios will be found the power factors tabulated in the right-hand column.

For example, if the reading of the reactive volt-ampere meter at any time is 33 kva. and the corresponding reading of the wattmeter is 100 kw., then the ratio of the first to the second is .33 and referring to the table, the power factor is 95 per cent.

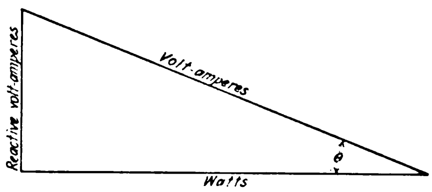
It must be understood that this reactive volt-ampere meter must be used in connection with a suitable transformer in order to displace the angle between the current and voltage by 90 deg. and, therefore, give the reactive or idle component of current.

JAMES B. HOLSTON.

Commercial Engineer,
Wagner Electric Corp.,
Chicago, Ill.

Referring to R.J.B.'s question, the function of a reactive volt-ampere meter is as follows: A reactive volt-ampere meter is a wattmeter so connected in the external circuit that it indicates the component of the total kva. which supplies the magnetizing power of the load, while a wattmeter indicates the power component. This meter measures the so-called idle or reactive component, which is at an angle of 90 deg. to the useful, or power component, which is known as the watt component.

The true relationship of the total load with its two components is shown by vectors in the accompanying diagram. In this vector diagram, it can be seen that when both types of meters are used, the total kva. load of the system can be found by extracting the square root of the sum of the squares of the two readings. When a reactive volt-ampere meter is use instead of a wattmeter, and it is desired to determine the power factor of the load, the



This diagram shows the relations existing between reactive kva., kw., and kva. and also shows the angle by means of which the power factor is computed.

following formula is used: reactive kva. $\div$ (volts $\times$ amp. $\times \sqrt{3}$) = sin θ, in which θ, is the angle of phase displacement, or the angle between the total volt-amperes and the true power component in watts as shown. The cosine of this angle is the power factor of the load.

The power factor of the load can also be determined from the wattmeter and kva. meter readings by the following formula: tan θ = watts $\div$ reactive kva., in which θ is the angle shown in the accompanying diagram. Cos θ equals the required power factor. For instance, assume that a wattmeter indicates 1,000 kw. while the reactive volt-ampere meter indicates 500 kva. The power factor of the load is then equal to the cosine of the angle whose tangent equals 500 $\div$ 1,000 = 0.5. The angle of which 0.5 is the tangent is 26 deg., 35 min. and the cosine of 26 deg., 35 min. = 0.89 or 89 per cent power factor.

The internal connections of the two instruments are identical, the difference being in the external connections. A wattmeter, to indicate reactive volt-amperes, must have the potential circuit excitation shifted 90 deg., since the readings of these two instruments are always exactly 90 deg. apart, as shown in the diagram. This shifting is done by a special tap transformer or by inserting a special external reactance in one of the potential leads. The connections of two graphic meters giving the above indications were shown in an article by the writer, published in the July, 1925, issue. H. E. STAFFORD.

Electrical Engineer,
Provincial Paper Mills Ltd.,
Port Arthur, Ont., Can.

In reply to the question asked by R. J. B., a reactive volt-ampere indicator is, as the name implies, a meter for indicating the reactive volt-amperes flowing in a circuit or machine. Reactive volt-amperes are the product of the reactive component of the current by the voltage. These indicators or what are very much like them—reactive factor meters—are highly recommended for use in place of a power factor indicator on rotary converters.

The reactive factor is the sin of the angular phase difference between voltage and current, or the ratio of the reactive power to the total kva., whereas, power factor is the cosine of the angular phase difference between voltage and current, or the ratio between true watts and apparent watts or total kva. In operation the power factor indicator reads 100 per cent when the power factor is unity and the reactive factor indicator reads zero. Under this condition the angular phase difference is zero, the current being in phase with the voltage and consequently there are no reactive volt-amperes flowing in the circuit.

A three-phase wattmeter indicates the true watts flowing in the circuit, providing it is an indicating wattmeter and not a watt-hour meter that R. J. B. has in mind. The true watts flowing in a three-phase circuit, indicated by the three-phase wattmeter, are equal to the product of the volts $\times$ amperes $\times$ power factor $\times$ 1.73.

Electrical Dept., FRANK AMMANN.
Sioux City Gas & Electric Co.,
Sioux City, Iowa.

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Replying to R. J. B.'s question, the function of a reactive volt-ampere meter is to measure the value of the product of the voltage multiplied by that value of the current which is 90 deg. out of phase with the voltage. This current is called the wattless or the reactive component.

A wattmeter measures the product of the voltage multiplied by the value of current which is in phase with the voltage. This current is called the power current or power component. The vector sum of these two values of current multiplied by the voltage represents the total volt-amperes in the circuit.

The usual three-phase watt-meter consists of the indicating instrument itself with two current transformers, which measures the current in two of the legs of the three-phase circuit, and potential transformers connected to give the correct voltage value and relation for measuring the power component in watts or, as is usually the case, in kilowatts. A three-phase reactive volt-ampere indicator might consist of exactly the same apparatus with the addition of a double auto-transformer in the potential circuits connected in such a way as to obtain voltage components of the circuits which are 90 deg. out of phase with their respective currents. The meter then indicates reactive volt-amperes or, as is usual, the meter is calibrated to read in kilovolt-amperes, indicating the product of the volts multiplied by the amperes flowing in the circuit and doing no actual work, but that are, nevertheless,

necessary for exciting or magnetizing apparatus such as motors or transformers which are connected in the circuit.

The greater the reactive volt-amperes in a circuit the lower the power factor. At unity power factor the reactive volt-ampere meter will read zero. Such a meter usually has its zero in the center and reads in both directions, thus indicating whether the power factor is lagging or leading.

Some power companies base their rates upon the amount of reactive volt-ampere hours in the circuit metered as well as the actual power in watt-hours or kilowatt-hours, and where such rates are in effect reactive volt-ampere-hour meters may be installed.

If R. J. B. ordered a three-phase wattmeter and received a reactive volt-ampere meter, a mistake was no doubt made and he should take steps to obtain the instrument he ordered as the operator usually requires a wattmeter rather than a reactive volt-ampere meter. L. T. JOHNSON.
East Cleveland, Ohio.

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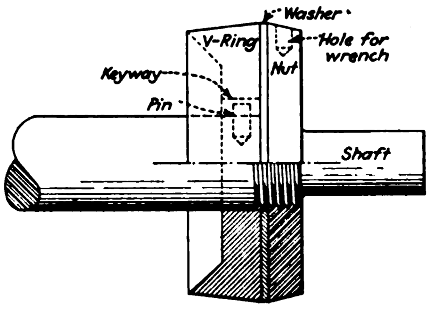
Trouble in Keeping Commutator Bars Straight.—I have considerable trouble in keeping commutator bars true and straight when the commutator is put back on the shaft of the armature after being repaired. The type of armature that I have particular trouble with is a ⅛-hp., d.c., No. A3, Westinghouse motor. The commutator is held in place by the front and rear V-rings which are locked in place by means of a plate screwed onto the armature shaft. In tightening this plate the armature bars move at an angle or become skewed. Can some reader tell me how to assemble these small commutators in such manner as to prevent them from skewing?
New York, N. Y. B. L. A.

Answering B. L. A.'s question on how to keep commutator bars from twisting while tightening the locking nut, there are several ways to accomplish this. One of the simplest ways is to put a metal washer between the metal V-ring and the nut, and then hold the bars from twisting with a chain pipe wrench while tightening the nut. This method mars the copper segments slightly. Twisted bars may be straightened back into position, even after the nut is tight, by turning them with the chain wrench.

Another way is to drill a hole in the circumference of the metal V-ring and by means of a spanner wrench keep the ring from turning while the nut is being tightened with a second spanner wrench. A third method, that requires more work, is to cut a keyway in the V-ring, and put a pin in the shaft to fit the keyway. The pin should not interfere with the nut, or prevent it from being drawn tight. Some manufacturers use this method of securing the commutator bars in place as standard practice.

Most manufacturers tighten the commutators in a press which clamps the V-ring in place and holds it there, while the nut is tightened. The nut itself is not used to tighten the bars; it merely holds the pressure obtained by the press. All of the above methods require a suitable wrench for tightening the nut. Some workmen try to set up the nut with a drift, but this only damages the nut and sometimes ruins it. I am taking it for granted that the commutator is only being re-



Method of anchoring V-ring to keep it from twisting commutator while tightening commutator nut.

A keyway is cut in the V-ring and a pin is put in the shaft to fit the keyway. The pin should be so located that it will not interfere with the nut when it is pulled tight.

paired, and that the bars were originally straight.

In refilling commutators with new bars twisting is often caused by using cast bars which are not carefully made. Again, the bars may have been stacked improperly in assembling and machined while twisted. Twists of this sort are hard to take out and it is sometimes necessary to change the position of the bars in the commutator, or shim up some of the mica segments at one end. In such cases it is simply a matter of cut-and-try until the desired result is obtained. C. B. KECK.
Cleveland Heights, Ohio.

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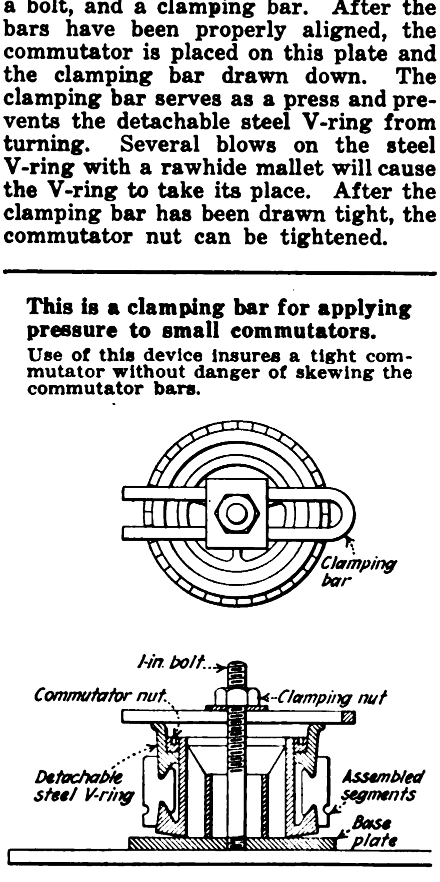
The skewing of the commutator bars encountered by B. L. A. can be prevented by placing the commutator on a clamping plate, as shown in the accompanying illustration. This clamping plate consists of a steel baseplate, a bolt, and a clamping bar. After the bars have been properly aligned, the commutator is placed on this plate and the clamping bar drawn down. The clamping bar serves as a press and prevents the detachable steel V-ring from turning. Several blows on the steel V-ring with a rawhide mallet will cause the V-ring to take its place. After the clamping bar has been drawn tight, the commutator nut can be tightened.

This is a clamping bar for applying pressure to small commutators.

Use of this device insures a tight commutator without danger of skewing the commutator bars.



Before applying the final pressure, the commutator assembly should be heated to a temperature from 125 to 150 deg. C. This will soften the bond in the mica V-ring, thus permitting it to adjust itself to the irregularities of the metal parts. If the commutator is tightened while cold, the mica V-ring will not conform itself to the metal parts because it is hard. If an excess pressure is applied to it under these conditions the bond will pulverize, causing crushed spots.

For small commutators, the clamping bar just described will furnish sufficient pressure to obtain a tight commutaor. However, on large commutators it will be necessary to use a press and a special wrench.

JESSE M. ZIMMERMAN.
Engineering Dept.,
Homewood Works,
Westinghouse Electric & Mfg. Co.,
Pittsburgh, Pa.

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I have found it necessary on some large commutators to block the armature and straighten commutator bars by using a jack; so I cannot see why such a method cannot be used on the smaller jobs, providing they became skewed after taking due precautions in putting the armature back in place.

In tightening a commutator, a ring tightly bolted around, but insulated from the armature, is of assistance in keeping the bars straight, and if the rear ring is screwed to position first and the final tightening done in the front ring, it will be of help. As a secondary measure I have found it of help to skew the bars slightly in the opposite direction and their tendency to straighten helps to tighten the retaining rings. However, it is preferable to get away from any skewing as the insulating ring is likely to be pinched and broken.

Heat applied to the commutator makes it possible to get a tighter fit, but also adds to the effort of keeping the bars from skewing. However, it is essential to have a well-seasoned job in order to avoid further trouble.

Chief Electrician, E. J. MORRISSEY.
Western United Gas & Electric Co.,
Aurora, Illinois.

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The trouble that B. L. A. has with his small armatures is a trouble that many winders have with the method of fastening the outside V-ring on commutators with a locking nut. This trouble may be prevented by cutting a small keyway in the clamping V-ring and putting a pin in the shaft so as to fit in the keyway. This pin must be placed so that the clamping nut will not bind upon it when the clamping nut is tightened.

This keying of the V-ring to prevent turning is not, however, applicable in every case. Another method is to wind a small or large loop, according to the size of the machine, several times around the commutator in a direction opposite to that of tightening the nut. The end of the rope may be held by means of a bar or with the hand. The nut is then tightened. This method usually holds the bars from twisting. In stubborn cases, draw the nut reasonably tight and then take a sharp cold

chisel or lead set and go around the commutator, driving the bars back straight. It will not hurt to skew them opposite to the direction the nut is turned in tightening. It may be necessary to go around the commutator several times. GRADY H. EMERSON.
Birmingham, Ala.

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Replying to B. L. A.'s question, I would say that his trouble is caused by friction betwen the retaining ring and the front V-ring while the ring is being tightened. I have experienced the same trouble, and here is the remedy: Drill a ¼-in. hole in the shaft at a point that will be under the V-ring after it is tightened. In this hole drive a pin, allowing it to project ⅛ in. File a slot or keyway in the V-ring to fit over this pin, as the ring is drawn down. This pin will prevent the V-ring from turning and the bars will remain straight.
Indianapolis, Ind. M. V. MILLER.

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Replying to B. L. A.'s question, the commutator should be built around a wooden mandril covered with grease, so that it can easily be removed. After all segments are in place, the commutator may be held together with friction tape until more permanent bands of fine brass wire can be tightly wound around it. A strip of mica should be placed under each band, so that when the bands are soldered, the solder will not adhere to the commutator bars. The mandril should then be removed and the commutator placed on the shaft and tightened. The bands may then be removed and the commutator trued in a lathe.
Electrical Engineer, H. E. STAFFORD.
Provincial Paper Mills, Ltd.,
Port Arthur, Ont., Can.

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Answering B. L. A., I am sure I can give him a remedy in a few words. The cause of the bars moving when tightening a commutator is that the front end ring moves, thereby throwing the front end of the bars out of line with the back end of the bars. If, when he starts to put a strain on the nut, he will place a Stilson wrench around the bars near the front and have someone put a tension on it in the opposite direction from that in which the nut is tightened, I am sure the bars will stay straight. Do not push or pull hard on the wrench as it is not necessary. Just merely hold a tension against the bars. Sometimes the wrench will press the bars in slightly but this can be easily remedied by tapping the bars with a hammer once or twice during the tightening, at the same time placing the wrench in a different position.
Darby, Pa. GEORGE WM. HANLON.

* * * *

Tests on Motors Do Not Check Nameplate Data — We have three 200-hp., 600-r.p.m., 60-cycle, three-phase, 440-volt, wound-rotor, induction motors, that are used to drive tube mills in our cement plant. According to the nameplate, the full-load, primary current is 245 amp., while the full-load secondary current is 346 amp. On making a test on one of the motors, I found that with the belt off the primary current was 125 amp. Upon putting the belt back on the pulley and loading the motor, the primary current rose to 275 amp., while the secondary current went up to 150 amp. Upon increasing the load, the primary current reached 350 amp. and the secondary current 275 amp. According to the nameplate the primary current should be less than the secondary current, while the tests show just the opposite. The temperature rise on the motors so far has stayed below 40 deg. Can some reader tell me what is the matter with these motors?
Ragland, Ala. R. I. F.

In response to R.I.F.'s query in regard to the operation of three 200-hp., wound-rotor motors, I would say that it is hardly possible that the trouble is in the machines, assuming that the application of machines and service are correct. I would recommend that he investigate as to the correctness of his tests and instruments, and venture to say that due to the fact that the frequency of a wound rotor is very much lower than that at which the stator operates, correct readings are not obtainable with some ammeters. I believe the difference between his tests and the nameplate ratings arises from this source. FRANK W. SLOAN.
San Diego, Calif.

* * * *

I do not believe that R.I.F. should be alarmed because the full-load secondary current of his wound-rotor induction motor is not so great as the value given on the nameplate. The secondary current given is that value of secondary current which would flow in the rotor circuit at standstill with full voltage applied to the primary winding. This is known as the locked rotor current and is obtained by blocking or wedging the rotor so that it cannot turn and gradually raising the primary voltage to the nameplate value and reading the secondary current which flows at that instant.

This is the maximum amount of current that can be expected to flow in the rotor circuit. The full-load secondary current will be considerably less than this value since it would occur only when the motor is delivering its maximum torque. The fact that the secondary current for the full-load condition is not so great as the nameplate value does not necessarily indicate any fault in the motor. L. T. JOHNSON.
East Cleveland, Ohio.

* * * *

In answer to the question by R. I. F., when measuring the secondary current of slip-ring induction motors operating at normal speed, it is necessary to remember that the current frequency of the secondary or rotor circuit is very low. As a matter of fact, the frequency of this circuit is equal to the slip of the motor.

The ordinary slip of induction motors is from 3 to 5 per cent. This means that the frequency in the secondary circuit is two or three cycles per second, when operating at full speed. When measuring the current in the secondary of a 200-hp., slip-ring motor, the natural tendency would be to use a current transformer connected to a 5-amp. meter. The reading of the meter would then be corrected in accordance with the ratio of the current transformer. However, these current transformers are ordinarily designed for a frequency of 25 to 50 cycles, and they will not read accurately on frequencies as low as two or three cycles per second. If the current in the secondary circuit is measured with the rotor locked, that is, with the rotor standing still, the readings obtained when using the current transformer and the 5-amp. meter will be accurate.

A meter which will measure the motor nameplate current probably could be used, although if this is done care must be taken to see that excessive current does not flow through it when the motor is started. This excessive current can be avoided by providing a heavy, single-pole, single-throw knife switch, which directly short-circuits the ammeter during the starting period. If this switch is opened after the motor is running, the reading can be taken without danger to the meter.

In discussing the actual current values recorded by R. I. F., it seems apparent that he has tried to use a current transformer, and this has resulted in a much lower reading than the value of the secondary current actually present, because of the very low frequency in the secondary circuit. It should be understood that the primary circuit of an induction motor refers to the stator windings, which are directly connected to the a.c. supply, and that the secondary or rotor circuit corresponds to the secondary of an ordinary transformer.

In making tests of this kind, care should be taken to see that the voltage on all three phases is maintained at practically the same value, and that this value is not more than 5 per cent less than the rating of the motor. In other words, on a 440-volt circuit the voltage must be maintained within 5 per cent of the 440-volt figure, if results are to be obtained which will agree with the nameplate data. It is also best to test the current in all three phases, or at least in any two of the lines, in order to make certain that balanced conditions are present.

Judging from the results R. I. F. obtained, that upon increasing the load the primary current became 350 amp., while the secondary current was only 275 amp., it might seem that the relative positions of the two windings of the motor had been misunderstood. However, it is believed that the error is in the use of a current transformer and that R. I. F. understands perfectly that the primary winding is the stator winding. This latter point has been suggested merely because it is very often overlooked.

JAMES B. HOLSTON.
Commercial Engineer,
Wagner Electric Corp.,
Chicago, Ill.

* * * *

In reply to the question by R. I. F., it is possible that the wrong nameplates have been used. R. I. F. should consult the manufacturer, as it would appear that the motors are under-rated according to the tests made, and the nameplate data.

The rated, full-load primary current is 245 amp. and, assuming a power factor of 80 per cent, $(245 \times 440 \times 1.73 \times .8) \div 746 = 200$ hp. Now, if he loaded these motors up to 350 amp., and the temperature increased less than 40 deg. after running for a long

period of time, it is quite evident that the motors are under-rated, because $(350 \times 440 \times 1.73 \times .8) \div 746 =$ 285 hp.

I think that if R. I. F. will make a very careful check of these motors, he will be in a better position to consult the manufacturer. My advice would be to use a polyphase wattmeter, a voltmeter and ammeters to check everything. It is possible that these motors have been rewound or reconnected in some way since leaving the factory, thus causing the readings to disagree with the nameplate data.

LEE F. DANN.
Chief Electrician,
Donnacona Paper Co., Ltd.,
Donnacona, Que., Can.

* * * *

Referring to R. I. F.'s problem, it appears as though the meter readings were somewhat twisted. It is stated that the full-load primary current is 245 amp. on a 40-deg. motor, but when 350 amp. or 42.8 per cent overload current is flowing through the stator windings, there is no increase in temperature.

The nameplate rating shows the full-load secondary current to be 346 amp. which corresponds very closely with the current which flows in the stator. The current of 125 amp. is approximately the friction load, rotor current, while the 275-amp. which flows in the rotor, is only 30 amp. above the rated, full-load, stator current. This is only 12 per cent above normal and would not heat the windings much above normal operating temperature, unless the motor were operating under this load for some time. It, therefore, appears as though the readings had been switched or that the leads to the rotor and stator had been mistaken in some manner.

About the only time that a wound-rotor motor will act in an abnormal manner is when one of the rotor leads is broken or disconnected. Trouble of this kind is readily determined, as the motor will run at approximately half-speed.

H. E. STAFFORD.
Electrical Engineer,
Provincial Paper Mills, Ltd.,
Port Arthur, Ont., Can.

What Causes Heating of This Cable Box? —There are six 1,000,000-circ. mil cables connected in parallel per phase on the cable run between our 2,000-kw. 3,000-amp., 480-volt turbo-generator and the oil switch. These cables are grouped in six conduits, each of which holds one cable from each phase, or a total of three cables. The conduits terminate in the bottom of a sheet-iron distribution box. In this box the cables are regrouped so that all of the cables from one phase go out of the left-hand side of the top of the box; all the cables for another phase go out through the center of the top of the box; and the six cables for the remaining phase go out through the right-hand side of the top of the box. With this arrangement the entire top half of the sheet-iron distribution box heats up. What causes this heating and how may it be overcome? Should I make the box of fiber instead of sheet iron.

Bellingham, Wash. E. M. D.

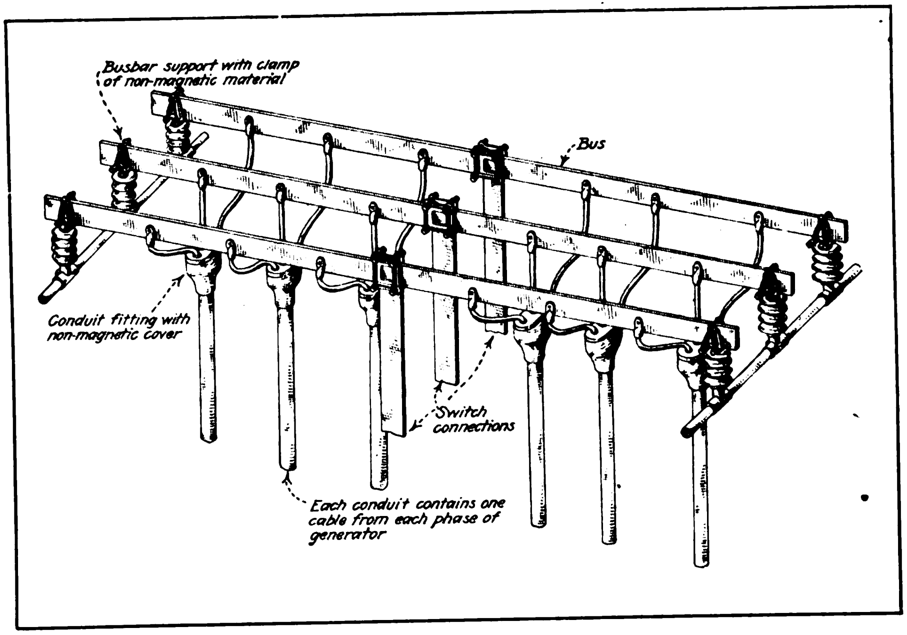
In answer to E. M. D., a conductor carrying current is encircled by magnetic lines of force. If the current is alternating, the magnetism varies in intensity and reverses with the current. When a conductor is surrounded by magnetic material this material is magnetized. Alternating current causes magnetic losses due to the changing flux and produces heat in proportion to the strength of the current in the conductors. E. M. D. states that he has carefully grouped the three-phase conductors in steel conduit, so that each conduit, on entering the bottom of the distribution box, contains one cable from each phase. By this method the magnetic field around the three-phase circuit has been balanced, which is the recognized way of overcoming this effect.

However, in taking the cables for each phase out separately through the top of the distribution box, an unbalanced condition is produced and heating of the upper portion of the box results. This can be prevented by making the distribution box of fiber, instead of sheet iron, as E. M. D. suggests.

I would recommend in most instances eliminating the box entirely and connecting the cables to a bus, as shown in the accompanying sketch. It is generally more satisfactory to use copper busbars on insulators, or racked cables in concrete tunnels, as feeders, when heavy currents are to be carried.

R. N. VINING.
Electrical Engineer,
Detroit Seamless Steel Tube Co.,
Detroit, Mich.

The use of distribution boxes for heavy feeder cables may be avoided by employing buses arranged as shown here



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Referring to the question by E. M. D. in regard to the heating of a cable box, this heat comes from eddy currents and hysteresis losses, just the same as the losses in a transformer core. To keep these losses within limits in a transformer, we take the precaution to select low-loss steel to decrease hysteresis and laminate the core to increase the resistance to eddy currents, but no such precautions are taken in the case of the cable box.

As the cables enter the bottom of the box, there are six complete, three-phase circuits, one in each conduit. Since the currents in all of the wires of a circuit are so opposed in direction that their algebraic sum is always zero, there will be no mutual magnetic effect between these circuits and consequently no flux in the bottom of the box. Through the top of the box, however, there is one phase of a 3,000-amp., three-phase circuit, with no neutralizing current to counteract it, passing through each hole. The current sets up a strong magnetic flux which flows through the top of the box. This flux causes hysteresis losses in the sheet-iron box and also sets up eddy currents causing local I^2R losses.

As a simple test of the above statements, may I suggest to E. M. D. that he place an iron bar between the lower circuits. He should find the bar practically free from alternating magnetism, and it will not become warm if allowed to remain. When the bar is placed between the upper circuits, the magnetic vibration will probably be felt, which will cause heat if the bar is not removed.

If E. M. D. will use fiber for the box instead of iron, as he suggests, there will be no further trouble from heat, provided there is no other iron between the circuits. If the circuits go through the top of the box in three conduits, however, I see no way of preventing the heat loss except by regrouping the wires in such a way that there are two cables of each phase in each conduit. In other words, the cables entering through any two bottom conduits should leave through one top conduit. E. M. D. is not the first man to get into trouble from grouping heavy a.c. conductors, in such a way that magnetic material can enter the loop of the circuit.

E. D. CARTER.
Engineer,
The Baylis Co.,
Bloomfield, N. J.

* * * *

Heating of the cable box mentioned by E.M.D. is caused by induction or eddy currents in the top of the box and is dependent upon a number of things such as the amount of current flowing in the cable passing through the top of the box, the frequency of the current, number of conductors, and the like. These eddy currents are caused by tak-

ing the conductors of each phase out in separate groups and can be prevented by bringing the conductors from each phase through the same hole in the box, or in the same manner as they are brought into the box from the bottom. Grouping the conductors from each phase in the same hole will allow the inductance of the cables of each phase to neutralize the others, thereby preventing the setting up of eddy currents. It is possible to make the cover of the box of a non-magnetic material such as fiber, asbestos and the like. This method without a doubt will correct the trouble that E.M.D. is experiencing.

Chief Electrician, E. J. MORRISSEY.
Western United Gas & Electric Co.
Aurora, Ill.

* * * *

In answer to the question asked by E.M.D., wherein he states he is having trouble from his cable box heating, I would say that the trouble is due to induction. According to his statement the cables are brought into the box with three cables in a conduit. Each of these three cables is from a separate phase and due to the fact that they are all in the same conduit, no eddy currents are set up in the conduits. The cables running out of this cable box are taken out with all of the phase leads grouped separately. Consequently, the points at which the different phase leads pass through the box cause the box to heat, due to the eddy currents set up in the top of the box.

In order to eliminate the heating, it is only necessary for him to take a hack saw and make a saw cut between the hole at the left-hand side of the box and the center hole and also between the hole at the right-hand side of the box and the center hole. This saw cut will break the circuit of the eddy currents and the heating will stop.

Longview, Wash. D. W. HAMILTON.

* * * *

In answer to E.M.D.'s question, the heating of the top half of the distribution box is caused by eddy currents which are induced in the sheet-iron box. The eddy currents are in turn caused by the self-induction of the conductors, the nearness of the iron, and the way the conductors are grouped on leaving the box.

If E.M.D. would group the cables on leaving the box the same way they are grouped when entering the box, or in any other arrangement as long as all the conductors from any circuit leave the box from the same outlet, he would have no further trouble from heating.

Newark, N. J. CHARLES H. MCSPIRITT.

* * * *

Answering the question by E. M. D. in regard to cable junction box heating, eddy currents probably are the cause of this heating and can easily be eliminated by making a non-magnetic junction box. A fiber cover on the box might help to prevent the heating. An easy way to find out is to remove the sheet-iron cover, so as to increase ventilation, and allow the cables to carry their load. If removing this cover fails to stop the heating, I would recommend the building of a non-magnetic box and the trouble will end.

It will not be necessary to put on the fiber cover until you have determined how much the cable box will heat, without a cover, when the cables are carrying full load. The fiber cover being non-magnetic, will not cause heating, although it will prevent cooling air from the room or pit from entering the box. LEE F. DANN.

Chief Electrician,
Donnacona Paper Co., Ltd.,
Donnacona, Que., Can.

* * * *

In answer to E.M.D.'s question, the trouble is probably due to eddy currents heating the top of the iron box, caused by grouping the cables of each phase separately.

We have overcome these faults in iron boxes by cutting a narrow slit between the three cable openings, so that a continuous path is not formed around the conductors of any one phase. These slits may be cut with an acetylene torch, or a row of small holes may be drilled close together and the remaining metal chipped out with a chisel.

Another method is to cut all of the iron between the openings and use a piece of fiber drilled out for the holes and screwed to the top of the iron box.

Summerset, Mass. H. EARL HERON.

* * * *

The following information may be of use to E. M. D., in explaining the reason why the top of his metal cable box has been heating up.

If two or more parallel conductors are carrying current in the same direction, the magnetic flux surrounding the conductors tends to draw them together. The lines of force around each conductor tend to unite with those of the other, forming a magnetic flux that encircles both the conductors.

Two parallel conductors carrying current in opposite directions are acted on by a force tending to separate them. As the lines of force in this case are opposite in direction, they cannot unite around the conductors, but must pass between, tending to crowd them apart. In some electrical machines, the stresses caused in this way oftentimes become of considerable magnitude when the currents involved are large. For example, short-circuits on large generators and transformers may cause great damage by tearing the conductors out of place, or by crushing the insulation on them.

Self-induction is the phenomenon whereby a change in the current in a conductor induces an emf. in the conductor itself. This induced emf. is always in such a direction that it tends to oppose any change in the current in the conductor, according to Lenz's law. The opposing emf. thus produced is referred to as the counter-electromotive force of self-induction. The value of the magnetic flux around any conductor depends on the strength of the current. Any change in the current causes a corresponding change of flux, and the change of flux induces in the conductor an emf. in such a direction as to oppose and retard the change of current.

If a conductor is surrounded by magnetic material this material will be magnetized. If alternating current is flowing in the conductor the rapid change of flux may cause much heating of any magnetic material that is close to the conductor.

On the other hand, if two conductors lie parallel to one another and the current in each is flowing in the opposite direction to that in the other, the field developed about one will oppose the field about the other. The result is that, if the conductors are very close together, the fields will almost entirely neutralize each other and there will be no appreciable self-induction.

The practical application of this is that if conduit is used, all wires of the same portions of an alternating-current circuit (feeder, main, or branch) must be installed in one conduit, in order to prevent self-induction and consequent heating.

In E.M.D.'s case, when the wires are brought out of the cable box in the proper order, there should be no heating.

As a possible remedy for the present conditions, if a fibre box can be made to withstand the conditions encountered, it should be used.

WILLIAM MCGUIRE.

Electrical Engineer,
Carbondale Machine Co.,
Carbondale, Pa.

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In reply to the question asked by E.M.D. concerning the heating of his cable box, I would suggest that he use some non-magnetic material such as brass or aluminum instead of sheet iron for the top of this box. Sheet iron is a magnetic material and when used where it is magnetized and demagnetized many times per second, as would be the case when it is placed around cables carrying 60-cycle current, this magnetizing and demagnetizing sets up eddy currents which heat the iron. If E.M.D. will use brass or aluminum for his box, I think his trouble will be eliminated.

Robertsdale, Pa. E. E. SIGEL.

* * * *

Heating of Commutator on Rewound Repulsion-Induction Motor — I recently rewound a G. E. single-phase ½-hp. four-pole type RI 110-volt repulsion-induction motor and am having trouble with it on account of heating. The commutator seems to heat first and in about two hours the motor gets so hot that you cannot put your hand on it, and it keeps on getting hotter. It does this when running idle. I have tested the commutator, armature, fields, and bearings and they seem to be O. K. The armature is well balanced. I used No. 16 d.c.c. wire in the rotor and main field and No. 18 in the compensating field. I shall appreciate any information regarding the cause and remedy of this condition.

Hubbard, Ore. R. S.

In reply to R. S.'s question, I wish to say that the trouble he is experiencing with a rewound repulsion-induction motor, is probably due to a defective short-circuiting mechanism. Motors of this type use the commutator for starting duty only. When the rotor gets up to a certain speed the commutator is automatically short-circuited, which makes the operation of the machine identical with that of a single-phase, induction motor. When the short-circuiting device is functioning properly, the commutator cannot heat.

L. KONSTAM.

Jones Electrical Repair Service,
New York, N. Y.

Electrical Service

around the works

For this section short articles describing ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing, and emergency or special installations.

Determining Power Factor With Watt-Hour Meters

THE subject of determining power factor was discussed on page 92 of the February, 1926, issue of INDUSTRIAL ENGINEER by James P. Marshall in a very comprehensive and detailed manner. Certain practical methods for obtaining the required results were covered which are readily applicable to the usual conditions occurring in actual practice. While no criticism is intended for the article mentioned, it is believed that some suggestions might simplify the method used and improve the accuracy of measurement.

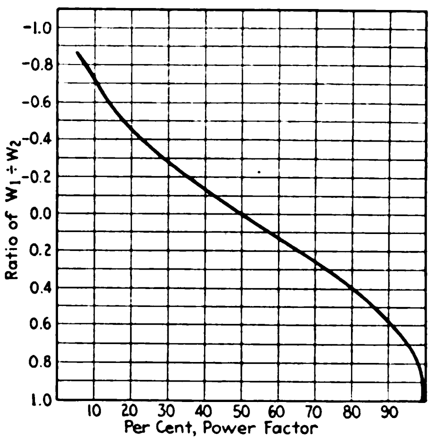
It is well known that the power in a three-phase circuit can be measured with a polyphase watt-hour meter having two potential and two current coils, or by two single-phase watt-hour meters. It is assumed that in the usual industrial installation, the load circuits are ungrounded. However, the necessary modifications can be made and the results obtained will not be affected when the following method is used.

Accordingly, it follows that the variation in the energy measured by the separate elements of the meter will depend entirely upon the power factor of the circuit. A very good example of this is a load having exactly 50 per cent power factor; if two single-phase watt-hour meters are used, the disk of one meter will stand still. The general formula for the energy of a three-phase circuit is: Total watt-hours = $W_1 + W_2$, where W_1 and W_2 represent the registrations of the separate elements of a polyphase watt-hour meter or the individual registrations of two separate single-phase watt-hour meters.

The test for power factor when the meter disks are visible may be conducted as follows: If the watt-hour meter is of the polyphase type, take the time of say ten revolutions of the disk without any change of connections, calling this result T_w. Then disconnect one of the voltage elements and again take the time for ten revolutions. The last test will probably take a longer period of time, or T_1. Knowing the meter constant and if the time is taken in seconds, the total load W_t in watts may be calculated by the formula: Watts = $(3{,}600 \times K \times R) \div S$, where K = watt-hour constant, R = number of disk revolutions, and S = time in seconds required for R revolutions.

The registration of the single element W_1 may now be obtained as follows: $W_1 = W_t \times (T_w \div T_1)$. The energy registered by the other element, W_2, may be found by using the formula $W_2 = W_t - W_1$. The power factor of the circuit may now be obtained as follows: Find the ratio of W_1 and W_2 by dividing the smaller by the larger value and substituting this value for X in the following equation: Power factor in per cent $= 100 \times \frac{1}{2} \times \sqrt{(1 + X)^3} \div (1 + X^3)$. For quicker determination of the power factor consult the accompanying curve, which only requires that the value of the ratio be calculated.

In connection with the use of the power factor formula, a word of caution should be noted. When the power factor is less than 50 per cent one of the meter elements will move faster when operating alone, while the other will reverse. In fact, if the power factor is exactly 50 per cent one of the elements will not revolve when the other is disconnected. If a polyphase meter is used for the test, equation $W_2 = W_t - W_1$ still holds good, except that if one element reverses its rotation, the value must be considered negative or minus. The equation would then become $W_2 = W_t - (-W_1)$ or $W_2 = W_t + W_1$, which shows that the element W_2 would speed up when operating alone. Accordingly the ratio of the smaller value of W divided by the larger would be negative, as is shown on the ordinate of the curve.



By means of this curve the power factor expressed in per cent may be found from the values registered by the individual elements of a polyphase watt-hour meter.

Using two single-phase watt-hour meters it is not necessary to calculate the load in watts as it may be obtained directly from the timing of, say, ten revolutions of each meter. Since the speed is directly proportional to the load the following relation is obtained: $W_1 \div W_2 = T_2 \div T_1$. Likewise, the same number of revolutions of the faster moving element multiplied by its load equals the time of the slower moving element multiplied by its load. The fact should also be remembered that in using two separate, single-phase meters, W_1 and W_2 are obtained separately from each meter. These values could be determined from the formula $W_2 = W_t - W_1$, by taking the time of each element separately. It might also be done as a check with a polyphase meter, although this is not actually necessary.

When the meter disks are not visible, the following procedure is required. This is not a frequent condition, but if encountered it will be necessary to take the time required by the meter dial to traverse one division of the smallest dial and calculate the actual load according to the formula: Kilowatt-hours per hour = (kilowatt-hours ÷ time interval in minutes) × 60 = kilowatts. This must be done as described previously for the visible type meter disk when one element is disconnected. However, in this case, we can modify the test very materially; as we have observed the time for the same watt-hour or kilowatt-hour registration, the time will be a measure of the load. The relation $W_1 \div W_2 = T_2 \div T_1$ is applicable; that is, the ratio of the element registrations may be obtained by dividing the lesser time by the greater and obtaining the power factor directly from the curve, or by the power factor formula as previously given.

In all of the foregoing tests it has been assumed that we are particularly interested in obtaining the power factor value. It is, however, readily possible, if the actual watt demand and power factor are known, to calculate the kilovolt-ampere demand by the formula, kva. = kw. ÷ P.F.

The description of this method of determining power factor has been given in considerable detail, but its application is exceedingly simple. Advantages that recommend its use are as follows:

(1) No voltmeters or ammeters are required.

(2) No inherent error is involved in calculating the kilovolt-amperes due to instrument errors and the difficulty of taking readings on an unsteady load.

(3) The method is inherently accurate, as the watt-hour meter is an accurate instrument.

(4) When a watt-hour meter is already installed, no additional test instruments of any kind are required.

This method has been used for a number of years in actual practice with excellent results. The writer, when an employee of a public service corporation, had occasion to observe that the customer's representatives were much more agreeable to having tests for power factor made in this way than with the many instruments, instrument transformers and complicated connections that would be otherwise required.

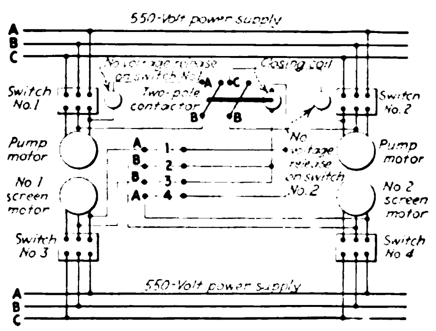
C. OTTO VON DANNENBERG.
Designing Engineer,
General Engineering & Management Corp.,
New York, N. Y.

Interlocking of Screen Motor Control Prevents Damage from Overflow

SOME paper mills are troubled with stock running over in screen rooms and flooding things generally. In our mill we have found a way to prevent this overflow by having the pump motors shut off automatically when the screen motors stop. The starters of the screen motors and the stock pump motors are so interconnected through the no-voltage release coils on the pump starters, that in case either screen motor stops, both pump motors are shut down.

This interconnection was made by the use of four fuses and a 550-volt, double-pole contactor with a single closing coil. The accompanying wiring diagram shows the arrangement and connections. It might be of interest to know that the pumps are in the basement and that the screens are located in a gallery on the first floor, the operator being unable to see the screen from where the pumps are located.

With the arrangement shown in the accompanying scheme, it is impossible to start either or both of the pump motors unless the proper number of screen motors have been placed in operation.



The coil of the contactor which closes the circuit to the no-voltage release coils for the pump motor control can be energized only when the screen motors are running.

This is accomplished by interlocking the control of the pump motors with that of the screen motors. In order to operate either or both of the pump motors, it is necessary to energize the closing coil of the interlocking contactor, which closes the circuit through the no-voltage release coils on the switches controlling the pumps.

Current for energizing the contactor closing coil can be obtained only when one or both of the screen motors are running, as follows: When screen motors Nos. 1 and 2 are running, fuses are placed across the dotted lines *1* and *2*. This connects phase A of screen motor No. 1 with the closing coil of the contactor through fuse *1*. The circuit is completed through fuse *2*, to phase B of screen motor No. 2. Since both screen motors are connected to the same power supply by means of switches *3* and *4*, current will flow from the A phase of No. 1 screen motor through the closing coil to the B phase of No. 2 screen motor, provided these motors are in operation. The contactor will then close completing the circuit through the no-voltage release coils on the pump motors, thereby permitting them to be started.

With screen motor No. 1 operating alone, fuses are placed across lines *1* and *3*. Phase A of screen motor No. 1 is thereby connected through fuse *1* to the closing coil and back through fuse *3* to phase B of the same screen motor. If No. 1 screen motor is in operation, current will flow through the closing coil as outlined, causing the contactor to close, thereby completing the circuit through the no-voltage release coils of the pump motor starters and permitting either pump to be started. When No. 2 screen motor only is running, fuses are placed across dotted lines *2* and *4* to complete the circuit in a like manner.

If for any reason the power supply to the screen motors fails, the contactor will open and cause the no-voltage release on the pump motor control to trip, thereby shutting down the pumps.

Inasmuch as the current drawn by the contactor coil is comparatively small, 1-amp. fuses are used. It will also be noted that only two fuses are in use at any time, thereby avoiding possible danger from short-circuits. Single-pole switches were suggested in place of the fuses, but they were not used because of the possibility of some unauthorized person closing all of the switches at once and receiving a severe burn or shock.

LEE F. DANN.
Chief Electrician,
Donnacona Paper Co. Ltd.,
Donnacona, Que., Can.

Ground Detectors for Use on Low-Voltage Systems

WHILE working in a certain shop a great deal of difficulty was experienced with grounds on both the 220-volt d.c. and the 440-volt a.c. systems, because there was nothing to indicate when a line became grounded. This led to the installation of two ground detectors made up of lamps as shown in Figs. 1 and 2. These detectors were placed on the end of the switchboard in the power house.

On the 220-volt d.c. system four 110-volt lamps were connected in series across the line. If 220-volt lamps are used only two would be required in series. Between lamps *2* and *3*, as shown in Fig. 1, a ground tap was made. When the system is clear of grounds the four lamps will burn equally bright at one-half voltage. If the negative line is grounded lamps *3* and *4* will cease to burn, while lamps *1* and *2* will burn at full voltage. A high-resistance ground will show up as an unbalanced condition in lights *1* and *2* against lights *3* and *4*.

For the convenience of the electrician a portable test box was made with four lamps connected the same as the ground detector in Fig. 1. This box was connected to the line by means of a two-conductor cable with Bull Dog connectors at the ends so that they could be quickly and firmly clamped to the busbars in any fuse box on the system. The ground wire was connected to the fuse box, which was metallic and permanently connected to ground. See Fig. 3 for illustration of these connections.

A few trouble cases will best illustrate the operation of this detector.

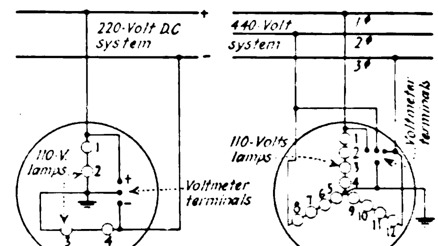


Fig. 1 Fig. 2

Figs. 1 and 2—Connection scheme for a ground detector using lamps.

In Fig. 1 is shown an arrangement using four 110-volt lamps for indicating grounds on a 220-volt system. Fig. 2 shows the connections for a detector used on a 440-volt, three-phase system.

One day the operator in the power house noticed that lamps *3* and *4* burned brightly, showing that the positive line was grounded. His instructions were to locate the ground by opening the switch of each feeder panel, one at a time, to see if the four lamps would burn with equal brilliancy at one-half voltage. When he opened the switch on feeder-panel No. 3 (Fig. 3) this condition was not fulfilled. The operator immediately knew that the ground was located on some line connected to this feeder-panel. He at once notified the electrical foreman who assigned an electrician to locate the ground. Feeder panel No. 3 had six fuse boxes each provided with a cutout switch, and all lines connected to these boxes were fused. In this manner a ground in any conduit or machine can be eliminated by disconnecting the line from the feeder box by pulling the fuse.

The electrician proceeded with the elimination process by going to fuse box *3-A* (Fig. 3). After connecting the test set to the fuse box and noting the difference in brilliancy in the lamps, he opened the disconnecting switch. This did not affect the condition of the lamps as lamps *3* and *4* still burned bright. Immediately he knew that fuse box *3-A* was clear of grounds. After connecting the test set to fuse box *3-B* he found that when he opened the disconnecting switch instead of lamps *3* and *4* burning bright and lamps *1* and *2* not burning at all, the four lamps burned with equal brilliancy at half voltage. This showed that the ground was located on one of the six lines which were connected to this box.

The next step in the elimination process was to test the six different circuits

by pulling a fuse on each positive line in turn and closing the disconnecting switch to see if the four lamps burned with equal brilliancy. When the fuse on circuit No. 5 was pulled and the disconnecting switch closed, instead of *3* and *4* burning bright, the four lamps burned the same. This showed that the ground was located on the positive side of circuit No. 5. The electrician immediately replaced the fuse and disconnected the electric equipment at the other end of this circuit. He then noted that lamps *3* and *4* on the test set continued to burn brightly. It was evident that the ground was between the fuses and the cutout switch at the motor. This also indicated that the positive wire was grounded in the conduit, which was true.

Another case of trouble that the operator noticed was that lights *1* and *2* burned very bright for a few minutes, but two or three minutes later lights *3* and *4* burned very bright. This indicated that the ground must be in some motor that was periodically reversed. This condition continued for several hours. The ground was found to be on feeder panel No. 1. All of the motors connected to this feeder operated continuously in one direction with the exception of the motors on a crane. It was plain that the ground was on one of the motors or the wiring of this crane. It was found that the armature trolley wire on the bridge which supplied power to the armature leads of the hoist motor was grounded.

During a third case of trouble, lamps *3* and *4* would burn very bright for a short time. For a period of approximately ten minutes the condition remained normal, then lamps *3* and *4* again glowed bright for a few minutes after which they became normal. Two hours later they again glowed brightly for a few minutes and during this time the operator was able to determine that the ground was on feeder No. 5. By analyzing the type of work done and the time of operating the equipment on this feeder line, it was decided that the ground must be on the electrical equipment that operated the turntable at the locomotive roundhouse. Investigation proved this assumption to be true.

This type of ground detector was also installed on the three-phase, 440-volt, a.c. system. Twelve 110-lamps were connected in three groups of four each in series, connected star across the three-phase lines, the center connection of the star being grounded as shown in Fig. 2. This placed eight lamps in series across each of the three phases. Half as many 220-volt lamps could have been used if desired. When the three lines were clear of grounds the 12 lamps would glow equally bright at half-voltage.

For example, let us assume that phase No. 3 became grounded. Under this condition lamps *9*, *10*, *11*, and *12* would not burn, while lamps *1* to *8* would burn at full voltage. For the electrician's use we made up a portable test box to connect to the fuse box, when testing for grounds on the a.c. system. This box contained 12 lamps connected the same as in Fig. 2. Bull Dog connectors were used on the leads so as to facilitate connections.

Before installing this detector, phase No. 3 had a ground which we were unable to locate. When the ground detector was connected, lamps *9*, *10*, *11*, and *12* did not burn at all while the rest burned bright. The first step in the process of elimination was to test out each feeder. This test did not change the condition of the lamps, which indicated that the ground was not on any of the feeder lines. We eliminated the motor-driven exciter by using a turbine-driven exciter, but still the ground remained. Alternately the four turbine-driven generators were taken off the line, but we were unable to locate the ground. Our next step was to disconnect the three-phase side of the two auto-transformers which were connected open-delta across the line for starting a large m.g. set (this being the only m.g. set directly connected to the bus). Immediately the 12 lamps glowed equally bright at half-voltage, thus indicating that this auto-transformer was grounded.

On another case of ground trouble, lamps *5*, *6*, *7*, and *8* went out and the rest of the lamps burned bright; then lamps *1*, *2*, *3*, and *4* were extinguished and the remaining lamps burned bright. Tests at the power house indicated that this ground was on the feeder supplying power to the scrap-yard crane, which was driven by three-phase, a.c. motors. Immediately we knew that the switching of the ground from one phase to the other was due to the switching of the primary leads on the motor when reversing the direction of rotation and, therefore, the ground was quickly located.

In conjunction with this type of ground detector, a daily check with a voltmeter showed up a great many high-resistance grounds. Each detector was provided with terminals so that the voltmeter might be quickly attached to the board. On the d.c. system the normal voltmeter reading from either line to ground was 110 volts, while on the a.c. system it was 220 volts. This would be true if the line voltage were 220 and 440 volts respectively.

On one occasion the voltmeter read 140 volts from the positive bus to ground. This indicated that there was a high-resistance ground on the negative line. When the voltmeter leads were switched to the negative line the voltmeter read only 80 volts. This sustained our belief that a high resistance ground existed on the negative side. As an aid in eliminating high-resistance grounds the test boxes were equipped with voltmeter terminals so that the electricians could connect the voltmeters to the test box and determine when he had eliminated the high-resistance ground.

This ground detector will work just as efficiently on a large d.c. system that is tied together as shown in Fig. 4. Such a system would likely be used in a large industrial plant. Let us assume a ground appeared on some line connected to substation No. 8; the operator in substation No. 2 sees that lights *3* and *4* are burning bright. Assume that the operator opens the tie line to substation No. 5; lamps *3* and *4* still burn bright. He then knows that the ground is not on the feeders radiating from this substation, and hence opens the tie line to substation No. 8. Immediately the four lamps glow equally bright at one-half voltage; this shows that the ground is on some of the feeders in sub-station No. 8. The operator in substation No. 8 must then be notified and he in turn will locate the feeder which is grounded and inform the electrical foreman. The responsibility for reporting grounds rest upon the station operator, who can generally be depended upon to make a complete report of any ground that might appear and how soon it was cleared.

J. M. ZIMMERMAN.

Renewal Parts Engineer,
Homewood Works,
Westinghouse, Electric & Mfg. Co.
Pittsburgh, Pa.

Figs. 3 and 4—Steps in locating a ground on a feeder supplying many circuits.

By means of the power house ground detector the ground was found to be connected to No. 3 feeder as shown in Fig. 3. By testing with the portable detector connected as shown, the ground was located on circuit No. 5. Fig. 4 shows how detectors may be used in substations that are tied together.

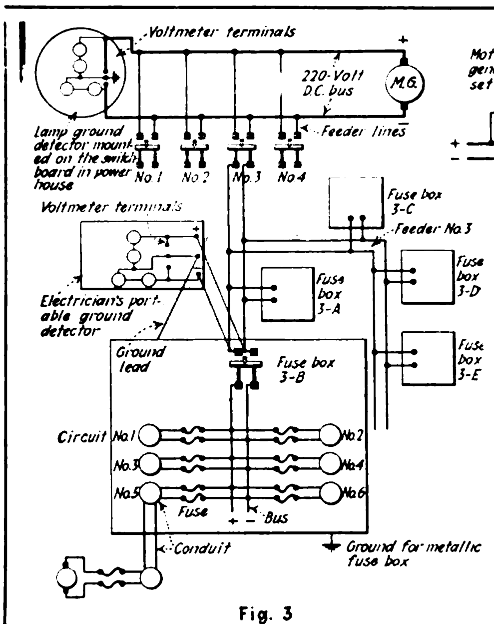


Fig. 3

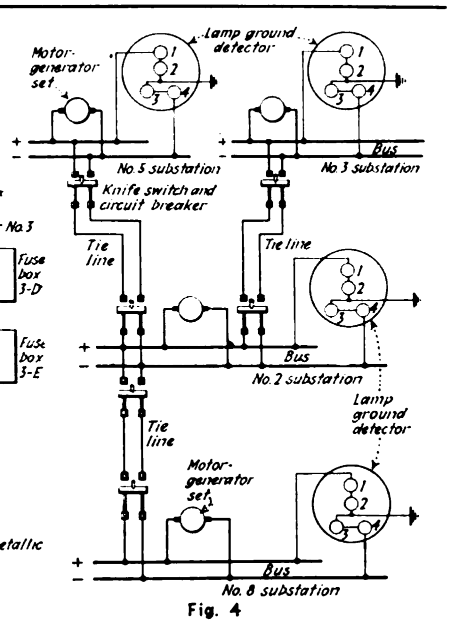


Fig. 4

Mechanical maintenance of

Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through the auxiliary transmitting equipment to all driven machines.

Chain Drives Increase Textile Mill Production

SMOOTH, continuous application of power is a very necessary factor in the drive of textile machinery. The importance of this and what it would do was not recognized in our 44,000-spindle mill until the 184 spinning frames were connected up with individual General Electric motors through Link-Belt silent chain drives. Ninety-four of these frames are driven by 5-hp. motors and chains, and the remainder by 7½-hp. motors and chains. Aside from the flexibility of the individual drive, the quality of our product has been wonderfully improved through the even and unvarying speed with which our frames are now being driven. Formerly the varying speed of the steam engine and the slippage of the belt which descended from an overhead lineshaft, resulted in considerable breakage of the yarn at the traveler.

This loss, which I estimated to be at least 6 per cent, has now been entirely eliminated. In consequence, production has increased 6 per cent which, with the 184 frames in operation, is equivalent to putting 11 extra frames on the floor. Because of the increased production obtained in the spinning department through the introduction of the individual drive, 48 more looms were installed. The gain from the 48 additional looms may be estimated at more than $4,000 annually which represents the profit resulting from the increased production, because of the change from steam power to individually-driven machines.

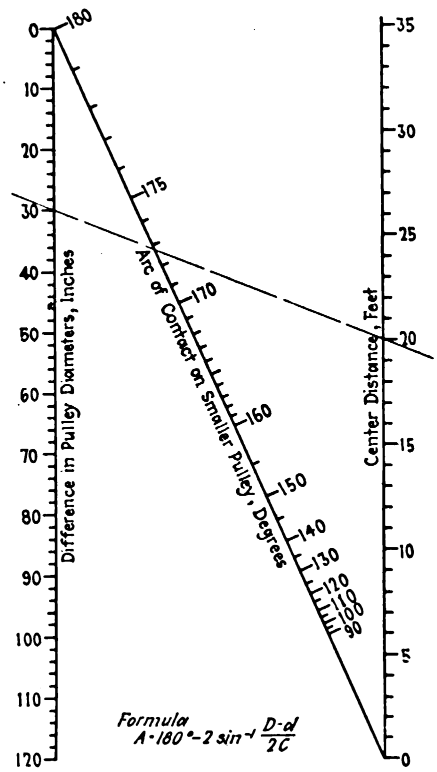
Superintendent THOMAS A. SIZEMORE.
American Spinning Company,
Greenville, S. C.

Chart for Determining Arc of Contact on Belt Drives

IN LAYING out a belt drive the arc of contact should be as close to 180 deg. as possible. A 180-deg. arc of contact is possible, however, only when both pulleys are of the same diameter. It is not considered good practice in any case to have the arc of contact on the smaller pulley less than 165 deg. Below that point a belt must be run at a very high tension to make up for the loss in arc of contact or some type of belt wrapping device used. If it is necessary to operate a belt at a lower arc of contact, allowance must be made in the capacity rating. For example, at an arc of contact of 160 deg., a belt will transmit only about 90 per cent of its rated capacity. With decreasing arc of contact the power-transmitting capacity decreases rapidly, until at 140-deg. arc a belt will transmit only 80 per cent of its rated capacity.

Wherever possible it is advisable to increase the distance between centers, which will increase the arc of contact. The accompanying chart may be used to determine quickly the arc of contact for various diameters of pulleys set at different center distances, until a satisfactory layout has been carefully established.

This chart is used on open drives where the belt is practically without sag. The method of using the chart is as follows: Locate the difference in pulley diameters in inches on the scale at the left, and the center distance in feet on the scale at the right. When these two points are connected with a straight-edge which may be either a fine thread, or preferably a celluloid rule, the arc of contact on the smaller pulley may be read off at the intersection of this line with the center diagonal line. The formula on which this chart is constructed is shown at the base of the chart.



Method of using chart for determining arc of contact.

This chart was prepared and copyrighted by J. E. Rhoads & Sons, Philadelphia, Pa. In the instance illustrated, the large pulley is 30 in. greater in diameter than the small pulley, and the center distance is 20 ft. The intersection with the center line of the line connecting these two points on the corresponding outside scales indicates that the arc of contact would be approximately 173 deg.

How Variable Speed Control Saves $15,000 a Year

IN OUR plant the cost of finishing ginghams has been materially reduced by the installation of two specially designed range finishing systems. The variable-speed transmissions, which control the speed of the tentering machines and starch mangles, play an important part in the success of this process.

Each system is composed of a brusher, a starch mangle, a tender range, a dryer, a series of callender rolls, and two Reeves variable-speed transmissions. With the exception of the brusher and the dryer fans, the entire system is driven by a 40-hp., variable speed, slip-ring induction motor, which is belted to a jackshaft.

The calender rolls are driven from this shaft by means of one Morse chain, while another Morse chain drives one sprocket on a No. 5 class G Reeves automatic, variable-speed transmission which, in turn, drives the mainshaft of the tentering machine through another silent chain. By means of bevel gears, this shaft drives a long shaft extending to the other end of the range, where the power is transmitted through a chain to a hand-controlled, variable-speed transmission. From this the starch mangle is driven through another chain.

The speed of the 40-hp. motor is regulated in accordance with the nature of the goods and the time required for drying. The speed of the tenter range is controlled automatically by the variable-speed transmission which is regulated by the compensator on the calender rolls.

When the texture of the goods changes, the floating roll on the compensator tends to rise or fall, but in so doing it affects the transmission, and causes it to adjust the tenter range speed so as to hold the floating roll in the correct position. The speed variations amount to about 2 per cent, although the transmission can easily care for a much wider range of speed.

The speed of the starch mangle is controlled in a similar manner, except that the transmission is controlled by hand. When the operator observes a change in the position of the floating roll on the mangle compensator, he adjusts the transmission so as to keep

the roll within its floating range. This is not quite so convenient as the automatic system, but we had been using these hand-controlled transmissions in another part of the plant and installed them here to save the expense of new ones.

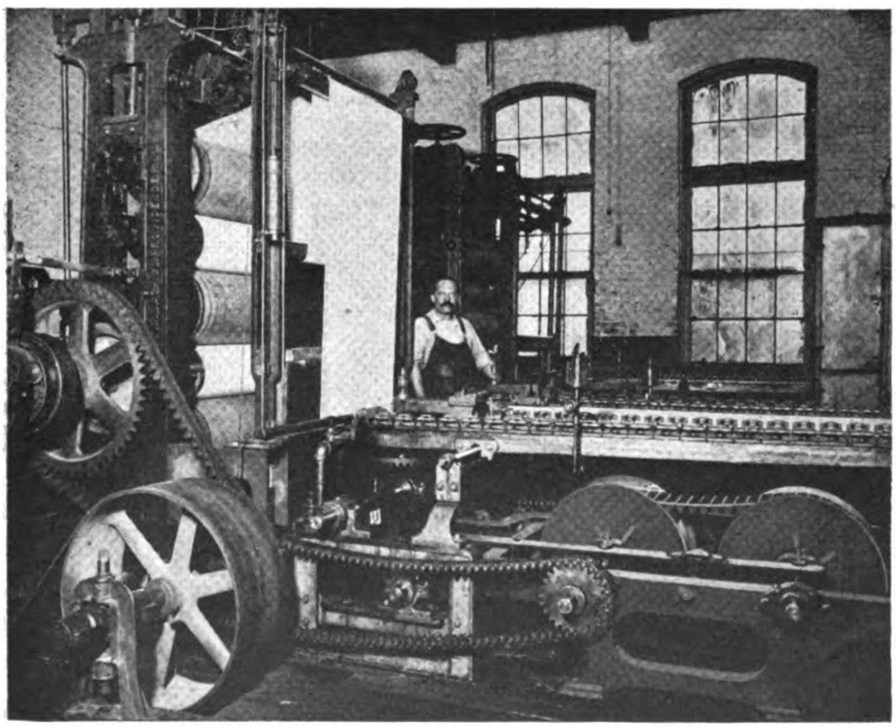
The transmissions have given entire satisfaction, and we have not spent one cent for repairs on them. We might have employed three synchronized motors for regulating the speed, but the cost of the motor-generator set, which would have been required, would have been about $1,500. In addition, the power cost would have been increased by using three small motors in place of a single large one. Each range now requires, by actual test, only 32 hp.

Finishing in range has resulted in important economies. Each of our present systems, using only one man, turns out 80 yd. per min. When brushing, tentering, and calendering were done in three separate operations, one tenter man and one calender operator turned out only 40 yd. per min. In other words, the new system has quadrupled the production per man. To obtain a production of 160 yd. per min. by the old method would require four calender operators and tenter men, or a total of eight men where we now use two. The saving in the labor of six men amounts to $7,800 per year.

An even greater saving has been effected by the great decrease in the percentage of narrows. Considerable trouble was caused by the frequent starting and stopping and by the goods running out from under the clamps.

Variable speed drive on tentering machine.

The speed of this 90-in. tentering machine is automatically controlled by the Reeves (Reeves Pully Co., Columbus, Ind.) variable-speed transmission unit in the foreground. This transmission keeps the tension of the cloth uniform between the tenter and calender and so prevents imperfect production.



The narrows have been reduced from 1 per cent to ⅛ of 1 per cent, a reduction of 87.5 per cent. This saves about 240,240 yd. of goods annually. Since we lose an average of 3 cents on each yard sold as narrows, we are saving $7,207.20 annually from this source.

The total saving amounts to $15,007.20 a year, and since the two ranges cost about $50,000 the net annual return on the investment is 30 per cent. This means that the new finishing equipment will repay its entire original cost every 3⅓ years.

It has also effected a saving in floor space, since the two new machines occupy no more space than the three old ones which were removed. In other words, we now get 160 yd. per min. from a space which formerly produced only 120 yd. per min. The variable speed transmissions have been an important factor in the success of our range finishing systems in that they add very little to the cost when compared with the increased results obtained from a $50,000 investment.

J. E. WILLIAMSON.

Superintendent, Finishing Mill,
Highland Park Mfg. Co.,
Charlotte, N. C.

Lubrication of Cranes and Hoists

(Continued from page 420)

time. Gears which are not enclosed may be lubricated by any of the special gear greases.

The lubrication of the mechanical brakes on cranes is a very important matter. These are run in a bath of oil which should be changed frequently. Also, the brakes should be taken apart and examined every six months at least for wear and adjustment. The lubrication of solenoid brakes should be taken care of as provided by the manufacturer. Care must be taken, however, that no lubricating oil is placed on the brake wheels of the solenoid or bridge brake.

The cable also needs frequent lubrication. For this purpose a mixture of linseed oil and graphite or similar, special, cable lubricants should be used. Ordinary lubricating oils should not be used.

Electric hoists offer a different lubrication problem. These units are usually more compact than are cranes and also the working parts are practically always enclosed. This makes it much easier to provide lubrication for most of the gears by means of the splash or oil bath system. The oil well is usually filled from the outside and has some sort of gage or other means for indicating the proper level. The frequency with which the oil should be drained from the compartment and refilled depends very much upon the amount of use and the conditions under which the hoist operates. The motor bearings are generally of the ring-oiling type or ball- or roller-bearing types, each of which has its own method of lubrication.

In the lubrication of a hoist, considerable attention must be given to the temperature under which it operates. Lubrication recommendations usually are included by the manufacturer for three different conditions: outdoor winter operation or around ice plants, operation under ordinary temperature conditions, and operation where the temperature is over 140 deg. F. Manufacturers of lubricants will supply oils for use in the different bearings and oil reservoirs suitable for these various conditions.

Another article to appear in an early issue of INDUSTRIAL ENGINEER will discuss some of the problems in the lubrication of conveyors.

EDITORS' NOTE: Acknowledgment is made to the following companies for assistance in supplying information and photographse used in this article: The Bassick Mfg. Co., Chicago, Ill.; Carr Fastener Co., Cambridge, Mass.; The Chisholm-Moore Mfg. Co., Cleveland, Ohio; The Cleveland Crane & Engineering Co., Wickliffe, Ohio; The Euclid Crane & Hoist Co., Euclid, Ohio; Harnischfeger Corp., Milwaukee, Wis.; Keystone Lubricating Co., Philadelphia, Pa.; Link-Belt Co., Chicago, Ill.; Northern Engineering Co., Detroit, Mich.; Shepard Electric Crane & Hoist Co., Montour Falls, N. Y.; The Yale & Towne Mfg. Co., Stamford, Conn.; Whiting Corp., Harvey, Ill.

In the Repair Shop

This section is devoted to repair work on electrical and mechanical equipment. Special attention is given to shop or bench tools and short cuts or improved methods of handling work of this character. Contributions are always welcome.

Comments on Various Methods of Cleaning Motors

THE question as to the best method of cleaning motor windings is an interesting and important one. It is also one on which there is some difference of opinion. I have used gasoline for cleaning windings, and alcohol for cleaning commutators and have never been able to find anything else that would clean motor windings of oil and sticky dust as well as they do.

I do not see any advantage in baking an oil-soaked motor; if it does anything baking would probably do harm because the oil that had partially solidified would be run into the cracks in the insulation by the heat. There might be some small advantage in heating the motor and then washing with gasoline, but I prefer to clean them cold. Of course, after thoroughly washing it would be a good idea, if a bake oven is handy, to give the winding a dip in baking varnish of high oil-resistant qualities. If the oven is not handy an air drying varnish can be had that is practically oilproof. It is generally conceded by all authorities on varnish that the amber- or orange-colored varnish is the more oilproof and the black varnishes are the more waterproof; that is, generally speaking.

The gasoline may be applied to the winding with a brush, a rag, or blow torch. It seems to me that dipping the motors in gasoline would be too expensive unless a large number of oil-soaked motors were to be cleaned.

Birmingham, Ala. GRADY H. EMERSON.

Changing Two-Phase Generator Winding to Three-Phase

A LARGE lumber concern purchased a second-hand, 90-kw., two-phase, 2,200-volt, 277-r.p.m., 26-pole, 60-cycle, engine-type, revolving field a.c. generator. After investigating the condition of the generator winding and the use of transformers to step down and convert two-phase to three-phase, it was decided to rewind the generator for three-phase, 550-volt service. This was thought advisable, as the 2,200-volt, a.c. winding had been damaged in shipment and the insulation was not in the best of shape for hard usage.

The 2,200-volt, two-phase winding was of the concentric-chain, hand-wound type, with the coil ends placed in two ranges, as shown in the accompanying diagram, the pole-phase group connections for each phase being made on opposite sides of the machine.

The two-phase, 2,200-volt winding data were as follows: 156 slots, 78 coils, each coil consisting of 20 turns of No. 10 d.c.c. wire, with a diameter of 0.102 in., two wires wide by ten deep per slot, all turns per coil and groups were connected in series. There were 39 coils per phase, or 26 short pitch, 1-and-5, coils and 13 long pitch, 1-and-7, coils. The arrangement and connections are shown in the diagram. All the straight coils are in the A phase and all the bent coils are in the B phase. The average coil pitch of the two-phase winding was $(4 + 4 + 6) \div 3 = 4.67$, based on a double and single coil grouping for each phase.

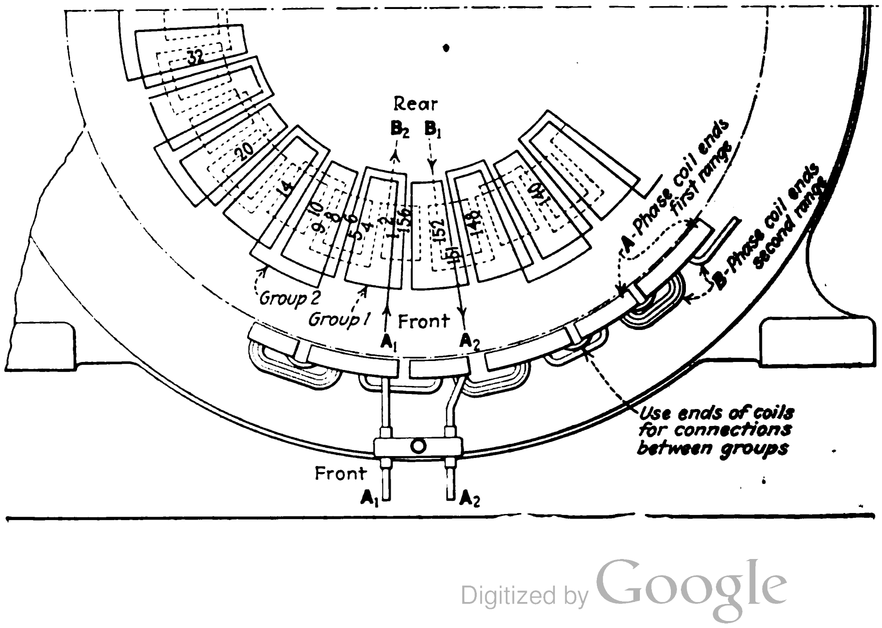
The method which was used in grouping the coils of the two-phase winding to obtain the least number of different size coils is interesting. Since the stator had 156 slots and 26 poles there would be $156 \div 26 = 6$ slots per pole, or for two phases $6 \div 2 = 3$ slots per pole-phase. The inside coil of each group would require three unfilled slots between coil sides for the second phase coil sides, or its pitch would be 1-and-5, or 4. The pitch of the middle coil would have to be 1-and-7, or 6, and for the outside coil would be 1-and-9, or 8. The average pitch for the three coils in this case would be $(4 + 6 + 8) \div 3 = 6$.

This results in three coils per group or six different coil sizes; that is, three straight, or A-phase coils, and three bent, or B-phase coils for the two ranges, or 13 coils of each size. With the 2-and-1 grouping shown in the diagram for this two-phase winding there are only four coils of different sizes; that is two straight and two bent for the A and B phases respectively. Only four different, size-forming blocks are required instead of six which would have been necessary with the three-coils-per-group winding. A saving in copper was also accomplished because the outside coil with the 1-and-9 pitch would extend out farther and have a longer pitch than is required in the 2-and-1 group winding.

The three-phase, 550-volt winding was figured as follows: The three-phase line voltage, using all the two-phase turns and a series-delta connection would be $(2{,}200 \times 2 \div 3) \times (0.966 \div 0.911) = 1{,}555$ volts. The figure 0.966 is the three-phase distribution factor for two slots per pole per phase, which is the number of slots for the new three-phase winding, as $156 \div 26 = 6$ slots per pole and $6 \div 3 = 2$ slots per pole per phase. The factor 0.911 is the distribution factor for the two-phase winding having three slots per pole per phase. It was impossible to rearrange the two-phase winding to obtain 550 volts, three phase, and as a complete rewind was necessary, the correct turns per slot for a 550-volt, three-phase series-delta connection is equal to $(550 \times 20) \div 1{,}555 = 7$.

The cross-section of copper must be increased in the same proportion that the turns per slot were decreased. One No. 10 wire has an area of 10,381 circ. mils; then the new size of wire in circ. mils equals $(20 \times 10{,}381) \div 7 = 29{,}660$ circ.mils. The nearest standard B & S gage size is one No. 5, with 33,102

Schematic diagram of a two-phase generator winding showing the original layout and connections of the coil groups and also a front view of the coil ends as they appeared in the machine.



circ.mils. The slot opening is 0.125 in. and the insulated size of No. 5 d.c.c. is 0.194 in.; therefore to make a two-layer, threaded-in winding, a smaller wire must be used. A wire size should be selected that will allow the use of a mush (hit and miss) wound coil to facilitate winding and handling of the coils. From a wire table, we find that eight No. 14 wires have an area of $8 \times 4{,}107 = 32{,}856$ circ.mils, which is sufficient copper.

Checking the slot room, the width of the slot is 0.423 in., allowing 0.066 in. for slot insulation; the wire space is then $0.423 - 0.066 = 0.357$ in. One No. 14 s.c.e. wire has an insulated diameter of 0.071 in.; therefore $0.357 \div 0.071 = 5$, or the number of wires that can be placed side by side. Since the coils are wound with seven turns of eight No. 14 s.c.e. wires, they will be $56 \div 5 = 11$ wires deep, or the depth of the insulated wire will be $11.2 \times 0.071 = 0.7952$ in. The depth of the slot under the opening is 1.406 in.; consequently we have ample room.

In order to provide more copper and a better insulated wire, we decided to try No. 13 d.c.c. and enameled wire. The insulated diameter of one No. 13 d.c.c. and enameled wire is 0.0827; $0.357 \div 0.0827 = 4$, or the number of wires possible to place side by side. The coils would be $56 \div 4 = 14$ wires deep, and $14 \times 0.0827 = 1.1578$ in., which indicates that using the larger size and better insulated wire, we would still have ample slot and end room. Two 0.023-in. fishpaper cells were used with a $\frac{1}{16}$-in. fiber filler in the bottom of the slots.

Also a treated-cloth slider, 0.01 in. thick, was used inside the fish-paper cells and allowed to project up above the core to protect the wire when winding it in.

It was decided to use the one-coil-per slot, two-layer, diamond-end, group type of winding, as this would require the winding and the handling of only 78 coils.

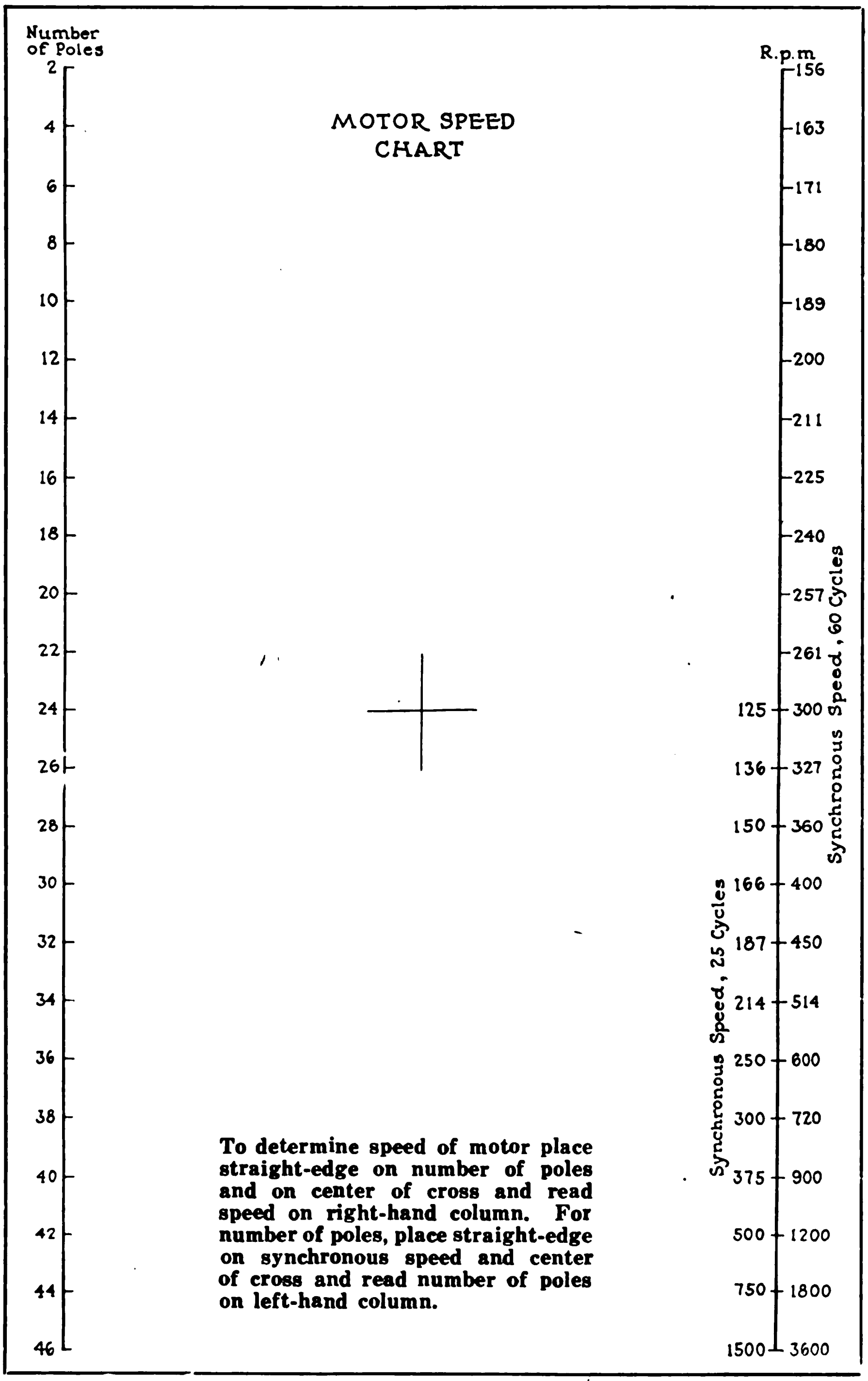
With this type of winding the coils are put in in groups. For example, with 78 coils, 26 poles, three-phase, one coil per slot, there will be $(26 \times 3) \div 2 = 39$ groups, and $78 \div 39 = 2$ coils per group.

Since the coils are put in in groups of two each there must be two slots between the inside coil sides, or the average coil pitch is 1-and-5, or 4, which is extremely close to the two-phase pitch of 4.67.

Thus, the three-phase, 550-volt winding consisted of 78 coils, each wound with seven turns of eight No. 13 d.c.c. and enameled wire, pitch 1-and-5, two coils per group, 39 groups connected series-delta.

All of the ends of the coils were taped with one half-lapped layer of 0.01-in. treated-cloth tape and one half-lapped layer of 0.007-in. cotton tape. The coils were of the mush puller type and provided, at a reasonable cost, a winding that will stand considerable overload without a serious rise in temperature.

Wilkinsburg, Pa. A. C. ROE.



To determine speed of motor place straight-edge on number of poles and on center of cross and read speed on right-hand column. For number of poles, place straight-edge on synchronous speed and center of cross and read number of poles on left-hand column.

Chart for Determining Speed or Number of Poles in Motor

WHEN making speed changes, and on other occasions, it is often necessary to determine the speed or number of poles in which the stator of an induction motor is wound.

If the frequency and either the speed or number of poles are known the other value may be found by means of the accompanying chart, which was drawn up to show the relation between the number of poles and the synchronous speed of induction motors operating at 25 and 60 cycles.

This chart is based on the formulas, $P = (120 \times F) \div$ r.p.m., and r.p.m. $= (120 \times F) \div P$, in which P equals number of poles, F is the frequency and r.p.m. represents the revolutions per minute.

When using the formula first given to determine the number of poles, the synchronous speed should be taken. The full-load speed must not be used, as it will not give a whole number of poles.

When using the chart to determine the number of poles, place a ruler or straight-edge on the synchronous speed shown in the left-hand column and on the center of the cross, and read the number of poles that is indicated in the right-hand column.

Should it be desired to find the speed with a given number of poles, place the ruler on the figure representing the number of poles and on the center of the cross, and read the speed on the left-hand column. CHAS. F. CAMERON.

Rock Springs, Wyo.

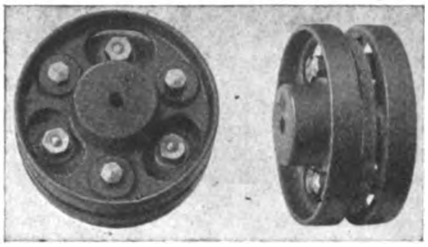
New Equipment

for plant operation and maintenance

Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these new devices which are designed to improve plant operation or reduce operating and maintenance costs.

New Flexible Shaft Coupling

NEW flexible shaft couplings are being marketed under the name of Flexoid, by the Smith Power Transmission Co., 1218 Ontario St., Cleveland, Ohio. Two views of this coupling are shown in the accompanying illustration. This coupling consists of two cast-iron flanges coupled together with one or



more flexible fabric disks in such a manner that there are no metal-to-metal bearing surfaces.

A joint of high strength and flexibility is claimed for this coupling which is designed to permit a 6-deg. misalignment of the shafts without chatter, according to the manufacturer, who also states that the fabric is especially treated, is impervious to oil and water, and insures complete electrical insulation of the sections of the shaft. No lubricant is required for this coupling.

These couplings are made in eight sizes with capacities from 0.2 to 10 hp. at 100 r.p.m. The manufacturer also states that these couplings can be used on reversing drives and other services with shock loads, as well as either horizontally or vertically.

Three-Element Watt-Hour Meter

A POLYPHASE watt-hour meter having three single-phase elements has been introduced by the General Electric Co., Schenectady, N. Y. Two designs are available, the side-connected, house-pattern, type D-9, and the back-connected, switchboard-pattern, type DS-9. The three-element type of meter, only recently developed, is intended for metering four-wire, three-phase circuits and is recommended where the highest accuracy is required, particularly when the circuit is unbalanced.

The same fundamental principle used in the two-element type of meter is utilized in the three-element types, in both service and switchboard forms. The meter is simply lengthened to accommodate another single-phase element which is attached to the base in the same manner as the other, and is equipped with the same balancing adjustments. The new meters embody the same features which characterize the two-element type, and, in addition, provide the extra element necessary for correctly metering on the three-wattmeter principle any four-wire, three-phase circuit.

This same construction is often useful for special metering applications such as totalizing two separate circuits, for example, a three-wire, two- or three-phase power circuit and a single-phase lighting circuit.

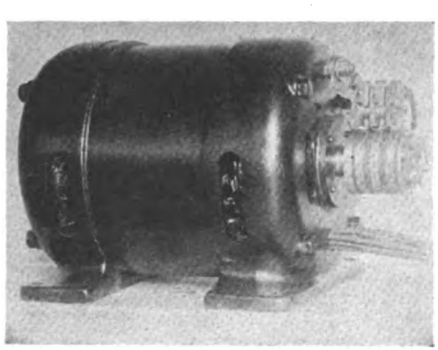
Frequency Changer for Operating Small Motors

THE frequency changer shown in the accompanying illustration has been designed and is being marketed by Forbes & Myers, 172 Union St., Worcester, Mass., for high-speed operation of individual small induction motors. This small, compact unit has the driving motor for the changer in the same frame and core as the frequency changer itself. In this illustration, the cover is removed to show the three rings for collecting the high-frequency current.

The unit illustrated is rated at ½ kva. for the operation of a ½-hp. motor. This particular unit operates on 220-volt, three-phase, 60-cycle current and delivers three-phase power at 60 cycles, 110 volts and 240 cycles, 270 volts. This unit is designed for the operation of a two-speed motor which is wound for 1,800 and 3,600 r.p.m. on 60 cycles. The 240-cycle current gives the two additional speeds of 7,200, and 14,400 r.p.m. on this same two-speed motor, which changes it into a four-speed motor.

High-speed motors are usually operated on three-phase current; however, the frequency changer can be built, it is stated, to operate on either two- or three-phase or even single-phase power and have the change made to three-phase power at the same time as the frequency is changed.

According to the manufacturer, the construction of this frequency changer is identical with that of a slip-ring induction motor, except that there are two independent windings in the same



slots of each rotor and stator. If additional frequencies are desired from the same frequency changer at the same time, they can be secured by using an additional winding for each additional frequency.

Gas-Electric Industrial Crane Truck with Magnet

AN INDUSTRIAL crane truck in which the power for operating the driving or hoisting motors as well as the lifting magnet is supplied by a gasoline engine and generator mounted on the truck in place of the storage battery, has been announced by the Baker-Rauling Co., Cleveland, Ohio. This is known as the type S-477 and has a capacity of 1,000 lb. on a 40-in. radius.

The accompanying illustration shows the use of this truck with a 20-in. circular type, Ohio Electric & Controller Co., Cleveland, Ohio, magnet designed to operate on 1,320 watts for handling castings in bags while loading or unloading from box cars or handling in storage. This magnet could be used as well for handling loose castings. It is said that in one instance this crane truck unloaded a car of loose castings in 45 min., the best previous record being 3 hr. for four men.

The power for operating the travel and hoisting motors as well as the magnet is supplied by a gas-electric unit manufactured by the Ready-Power Co., Detroit, Mich. This unit consists of a compound-wound, ball bearing generator with a maximum capacity of 250 amp. at 30 volts, which is connected by a silent chain drive to a four-cylinder, Continental gasoline engine operating at 1,000 r.p.m.

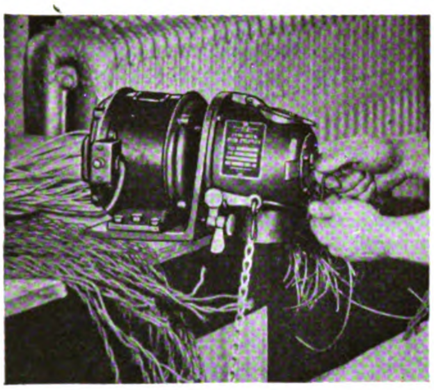
Temperature Overload Relay

REDESIGNING of the temperature overload relay TC-121 has been announced by the General Electric Co., Schenectady, N. Y. This relay has two heating elements connected in each two phases, so that complete protection is provided for single-, two- or three-phase motors. On d.c. circuits, the heating elements are connected on each side of the line. The improved relay is known as the form C, or TC-121-C. According to the manufacturer, the improvements in design allow the use of renewable heating elements, prevent the bending of thermostatic strips by operators, and include a better mechanical construction. The relay is reset by means of a cord and button suspended from the bottom.

Motor-Driven Wire Stripper

A MACHINE for stripping the insulation from the ends of wire is being put on the market by the France Wire Stripper Co., 255 Erie Bldg., Cleveland, Ohio. This device, known as the "Speedcraft Wire Stripper," consists of revolving knives that are driven by a motor. The distance between the cutting edges of the knives is adjustable for removing insulation from different sizes of wires. The length of the stripped portion is also controllable.

The machine twists together the strands of wire at the same time that the insulation is removed. However, the manufacturer states that none of the strands will be cut off during the



operation, for the depth to which the knives cut is set by means of a positive stop which permits the removal of all of the insulation without injury to the conductor. Standard machines will handle any size of wire up to a diameter of ½ in. over the insulation, and will strip the insulation off the end for any desired length up to a maximum of 3¼ in.

Portable Electric Pipe Machine

ANNOUNCEMENT is made that Hall-Will, Inc., Erie, Pa., have placed on the market the Red-E-Hall portable electric pipe cutting and threading machine which will handle ¼-inch. to 2-in. pipe, and ½-in. to 1½-in. bolts. It is stated that this machine may also be used as a power unit by connecting in a universal shaft to drive hand stocks up to 12 in. While this tool is designed as a portable machine, it can be changed over to a stationary machine by removing the wheels and bolting down.

The machine is of malleable-iron and steel construction and weighs 450 lb. Portability is obtained by a built-in truck with double swivel casters at the front, which elevate the front of the machine when the handle is moved forward.

The friction clutch for starting and stopping is operated by the lever handle at the top of the machine. The drive is obtained from a 1-hp., 1,750-r.p.m., reversible motor bolted directly to the main frame, as shown. This motor is connected to the head by a silent chain drive and is operated by push or turn-button control with stop, start, and reverse control attached to the outside of the bed where it is convenient for the operator.

Timken roller bearings are installed on all drive shafts. This pipe machine has three speeds, including an extra fast, for cutting off. All gears and shafts run in oil and speed changes are made by a selective sliding gear system with a neutral position between all shifts. All oil for cutting is supplied by a rotary, geared, reversible oil pump driven directly from the motor at constant speed. A large oil reservoir is mounted on the frame.

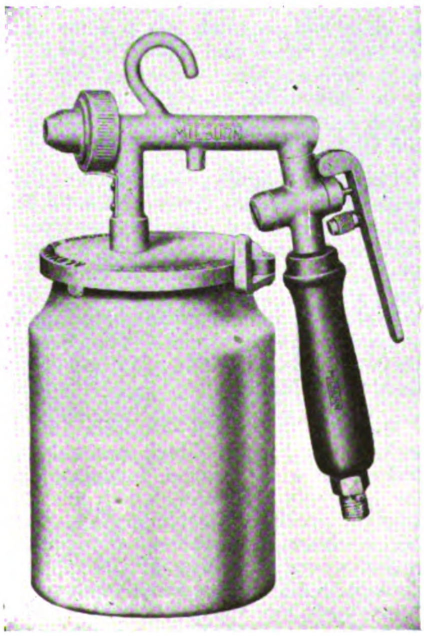
Portable Acetylene Generators

ANNOUNCEMENT is made by The Bastian-Blessing Co., 240-258 E. Ontario St., Chicago, Ill., that the new, portable Rego type PA acetylene generator has been listed as approved by the Underwriters' Laboratories. This generator is made in 30- and 60-lb. capacities in both portable and stationary types, which have normal generating capacities of 30 and 60 cu.ft. per hour respectively and maximum capacities twice as great.

New Paint Spray

EASE and simplicity of operation are claimed as the outstanding features of the new Milburn paint spray, shown in the accompanying illustration, which has recently been announced by Alexander Milburn Co., 1416-1428 Baltimore St., Baltimore, Md. In this device the paint enters a large annular chamber surrounding the air nozzle, from which it is atomized and expanded in a venturi-shape. The atomization is regulated by a turn of the nozzle from a small to a large spray, or is entirely shut off, which brings into play a stream of air for dusting purposes. An air pressure of 40 lb. is ordinarily used, but this can be varied to suit the work. Carbonic acid gas tanks may be used with the spray, it is stated.

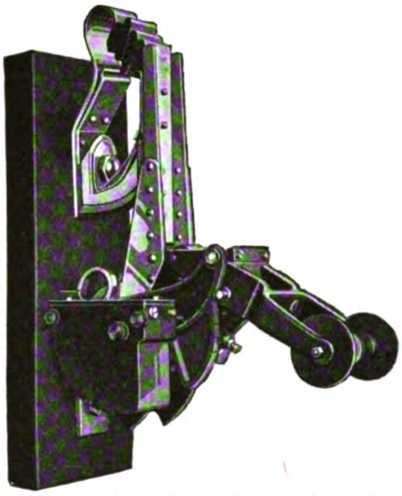
The manufacturer asserts that this paint spray is light and employs a simplified principle of construction which accounts for the absence of



moving parts and passages which may clog. This spray may be used for coating either walls or irregular surfaces with paint, varnish, oil or other similar coatings.

Direct-Acting, Time-Limit Attachment for Circuit Breakers

NEW attachments for standard-type circuit breakers, which prevent the latter from opening until an abnormal current has existed for an unusual length of time, or where there is an overload of such high value as to be



equivalent to a short-circuit, have been announced by the Roller-Smith Co., 233 Broadway, New York, N. Y. These direct-acting, time-limit attachments are designed especially for use where circuit breakers are used for motor protection because the starting current on the majority of motors is considerably in excess of the running current, thus necessitating the use of a circuit breaker which will not open during the normal starting period.

This attachment consists of paddles which are mounted in a cast, quadrant-shaped chamber filled with oil. The operation of the device is described by the manufacturer as follows: When the circuit in the overload coil of the breaker increases to the point where the magnetic pull of the core, is sufficiently strong to attract the overload armature this armature is attracted upward in exactly the same fashion as on a regular breaker. The upward motion, however, is retarded by the suction which exists between the paddles. Because of the accurately ground surfaces of these two paddles and the fact that they are submerged in oil, a comparatively strong pull must be exerted to separate them. If the pull of the overload core pin continues long enough or reaches a high point, due to a very heavy overload or short, the seal between the two paddles is broken and the armature rises, which instantly drives the handle and lever over and trips the breaker in the conventional manner.

This direct-acting, time-limit attachment is secured to the outside housing of the outside poles on multiple-pole breakers by means of two bolts. The time-limit attachments are shipped mounted on the breaker, but without the oil, which is supplied and shipped in a separate can.

Trade Literature

you should know about

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Man-Cooling Fans—A circular describes the Giant Portable Man-Cooler. —American Blower Co., Detroit, Mich.

Power-Factor Correction — Bulletin 146 relates the experience of the American Gas & Electric Co. in power-factor correction by the consumer.—Wagner Electric Corp., St. Louis, Mo.

Motors—A circular illustrates and describes the stator construction and field windings of Century squirrel-cage, polyphase induction motors.—Century Electric Co., 1806 Pine St., St. Louis, Mo.

Belt Clamps—A circular illustrates the application and the advantages of Petrol belt clamps for use in connecting fabric base belts on heavy-duty service.—Victor Balata & Textile Belting Co., 38 Murray Street, New York, N. Y.

Safety Lubricator—A 48-page booklet of questions and answers discusses lubrication problems and their solution by means of the Keystone Safety Lubricating System. A number of illustrations show applications in different industries.—Keystone Lubricating Co., Philadelphia, Pa.

Belt Adjuster—A circular describes the Medart short-center belt adjuster for use on open belt drives where the centers are close and speed reductions high.—The Medart Co., Potomac & De Kalb Sts., St. Louis, Mo.

Steel Roofs—A new booklet entitled, "Truscon Roofs of Security," illustrates the application of Ferrodeck and I-Plates steel-deck roofs for making permanent light-weight non-combustible roofs for all kinds of buildings.—Truscon Steel Co., Youngstown, Ohio.

Tool Steel Pinions—Circulars and bulletins describe the advantages of using hardened, tool steel pinions and gears and the savings possible over the use of parts made of untreated material.—The Tool Steel Gear & Pinion Co., Cincinnati, Ohio.

Roller Bearings—A circular entitled, "Hyatt Roller Bearings for Your Mill and Crane Type Motors," gives a diagrammatic illustration of an adapter for replacing existing plain bearings in several types of mill motors with Hyatt bearings.—Hyatt Roller Bearings Co., Newark, N. J.

Whiting Products—Catalog 175 under the above heading is a condensed catalog of the equipment manufactured by the Whiting Corp., and its subsidiaries. The Whiting products consist of cranes, foundry equipment, railway equipment, special machinery. Products of the subsidiaries are evaporators, crystallizers, pulp mill and sugar machinery, and pulverized coal systems.—Whiting Corp., Harvey, Ill.

Air Filters — A 32-page catalog describes the construction and operation of the Phoenix constant-effect air filter, in which the air passes through a rotatable screen covered with a viscous film. — Drying Systems, Inc., 1800 Foster Ave., Chicago, Ill.

Steel Belt Lacing—A circular gives the advantages gained, illustrates the application, and lists the sizes of Alligator steel belt lacing for belts of various thicknesses. — Flexible Steel Lacing Co., 4607-31 Lexington St., Chicago, Ill.

Distribution and Street Lighting Equipment — Sectional Catalog 26 covers a line of street lighting equipment and accessories as well as a line of specialties, distribution equipment, protective devices and pole line hardware manufactured by this company.—Line Material Co., So. Milwaukee, Wis.

Crane and Hoist Lubrication—Lubrication Bulletin 98 discusses and illustrates with phantom views the method of lubrication of the various types of electric cranes and hoists manufactured by this company.—Shepard Electric Crane & Hoist Co., Montour Falls, N. Y.

Grounding Devices—A 6-page circular gives data on Copperweld non-rusting ground rods and describes and lists such equipment manufactured by this company. Another bulletin discusses "The Electrical Characteristics of Driven Grounds."—Copperweld Steel Co., Braddock P. O., Rankin, Pa.

Wire Rope—An 88-page Wire Rope Users' hand book and price list discusses recent developments in wire rope making and contains the regular catalog descripton and specifications for wire rope and auxiliaries, as well as a large amount of engineering and operating data.—American Cable Co., Inc., 105 Hudson St., New York, N. Y.

Flexible Couplings—A folder illustrates four special types of Fast's flexible couplings and describes the special service for which they are designed. These couplings include the mill type, cut-cut type, and telescopic couplings, as well as a special double coupling for excessive misalignment.—The Bartlett Hayward Co., Scott & McHenry Sts., Baltimore, Md.

Manual Controllers—Bulletin 100 describes the line of Clark manual controllers of an improved, faceplate type for heavy-duty service, which are suitable for overhead electric cranes, charging machines, mill tables or any application where reversing of the motor is necessary and where hard operation is suitab'e.—The Clark Con'roller Co., 1146 E. 152nd St., Cleveland, Ohio.

Disc Clutches—Bulletins describe the new Edgemont type E disc clutch for use on lineshafts.—The Edgemont Machine Co., Dayton, Ohio.

Fuse Disconnects—Bulletin 118 illustrates and describes the line of Three-E outdoor expulsion fuse disconnects.—Electrical Engineers Equipment Co., Chicago, Ill.

Welding and Cutting Apparatus—Catalog 172C, vest-pocket size, describes the Milburn welding and cutting apparatus and welding generator.—The Alexander Milburn Co., Baltimore, Md.

Pole Line Hardware—Catalog 612 lists, describes and give specifications of the Truscon hot galvanized pole line hardware and specialties.—Truscon Steel Co., Youngstown, Ohio.

Bakelite Applications — A 32-page reprint of a multiple-page insert of advertising of Bakelite and Bakelite users shows a wide variety of applications of this product.—Bakelite Corp., 247 Park Ave., New York, N. Y.

Automatic Pumping—The 24-page Booklet 400a treats this subject from a purely technical standpoint and gives several new methods of making centrifugal pumps automatic.—Barrett, Haentjens & Co., Hazelton, Pa.

Cotton Mill Lighting—Booklet I-3 discusses the problems connected with the lighting of the various departments of cotton mills.—National Lamp Works, General Electric Co., Nela Park, Cleveland, Ohio.

Lubricating Equipment—Pocket-size catalogs describe the Detroit force-feed oilers for continuous lubrication of a number of bearings on pumps, compressors, engines, and other machinery.—Detroit Lubricator Co., Detroit, Mich.

Steel Belt Lacing—Catalog 22 illustrates the application and lists the various sizes of hooks and the different lacing machines for connecting belts.—Clipper Belt Lacer Co., 974-1042 Front Ave., N. W., Grand Rapids, Mich.

Tramrail Systems — A series of folders illustrate a number of applications of Cleveland tramrail systems handling material in process.—Cleveland Electric Tramrail Division of the Cleveland Crane & Engineering Co., Wickliffe, Ohio.

Non-Metallic Gears—A booklet discusses the uses and advantages claimed to result from using silent gears of Fibroc for industrial purposes. Particular attention is called to the Fibroc GR self-lubricating gear material which is impregnated with graphite.—Fibroc Insulation Co., Valparaiso, Ind.

Industry's Electrical Progress—Publication C-37 under the above title is an interesting 36-page booklet bound in board. This book shows in a non-technical way the growth of the application of electricity to industrial purposes, the progress made in the design of electrical equipment, and gives numerous non-technical but interesting examples of results accomplished by the use of correct motor control equipment. Many actual installations are shown. A copy will be sent upon request on a business letterhead.—The Cutler-Hammer Mfg. Co., 150 12th St., Milwaukee, Wis.

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

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Trends and New Practices in

Use of Power Drive Equipment

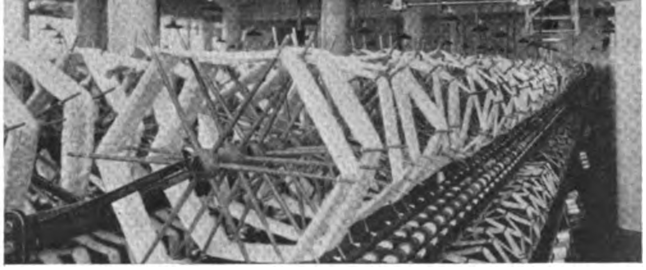
which includes a discussion of some outstanding developments in the design and application of devices employed to connect the motor to its load

By **FRANK E. GOODING**
Associate Editor, Industrial Engineer

BEFORE the advent of the electric motor into industry and for some time afterward practically all machinery was driven from lineshafts which, in turn were connected to steam engines or waterwheels by belts or ropes. As large engines were more economical, the size of these lineshafts was increased both in length and in diameter until it was not uncommon to use shafts from 4 to 6 in. and even larger in diameter, and often over 200 ft. long. Frequently, the lineshafts on several floors of a mill or factory were driven by a single engine through a complicated connection of mainshafts, jackshaft and clutches.

Large shafts require large bearings and heavy belts which, in turn, necessitated heavy pillow blocks, floor stands or hangers. Also, it was the general practice to step down the diameter of the shaft with the increase of the distance from the driving pulleys or sheave, which resulted in a nightmare of sizes of shafts and bearings, and pulleys with a wide variety of bores. The advent of the split pulley with adjustable bushings solved the pulley problem to a certain extent. The industrial period just described was one of complete mechanical drive.

In those days when the entire transmission line was practically a single inter-connected unit, or at least entirely dependent upon the central main driveshaft, a bearing failure in an important location would often shut down the entire plant. One of the main requisites of the Master Merchanic or Millwright in charge of the transmission line was the ability to "nurse" a hot bearing until quitting time. Each man had his own remedy, such as salt water, beer, and many "mysterious" concoctions of which he alone knew the recipe. When a bearing became dangerously warm, a man was stationed at it to flood it with his favorite cooling solution. Scientific lubrication and a knowledge of methods of reducing friction were unknown.



This JFS variable-speed transmission is installed in a Midwestern silk mill.

This is a new type of variable-speed transmission, the construction of which is explained and illustrated on page 495. The crank, which is mounted below the platform, operates the sprocket speed-changing wheel on the unit by means of the chain. In textile mill work, the variable-speed transmission is of special advantage in obtaining the proper speed for any condition of humidity, quality, or size of product.

With the perfection of electric motors many of these engines were scrapped or connected to generators, and the motors belted up to lineshafts which, in many cases, were merely sections of the old shaft. As a result, many of these shafts were larger than necessary and had heavy friction losses in old bearings. Because it was easier to measure the power used by a motor than by an engine, industrial operating men began to study the load on the motor both with and without the machine load. It was in this way that the heavy friction loss of the old-type, oversize lineshaft, operating in plain bearings, was discovered.

Some industrial men became convinced that the way to eliminate this friction loss was to take out all the shafting and bearings and connect the motor to the individual machine. Several textile mills where, in addition to the friction loss, oil dripping from overhead bearings caused considerable damage to the product, made installations in which each machine had its individual motor. These installations were described in the technical press and discussed extensively in engineering gatherings. As a result, about 10 or 15 years ago, industry in general be-

gan to take a decided trend toward individual motor drive. That may be called a period of electric drives.

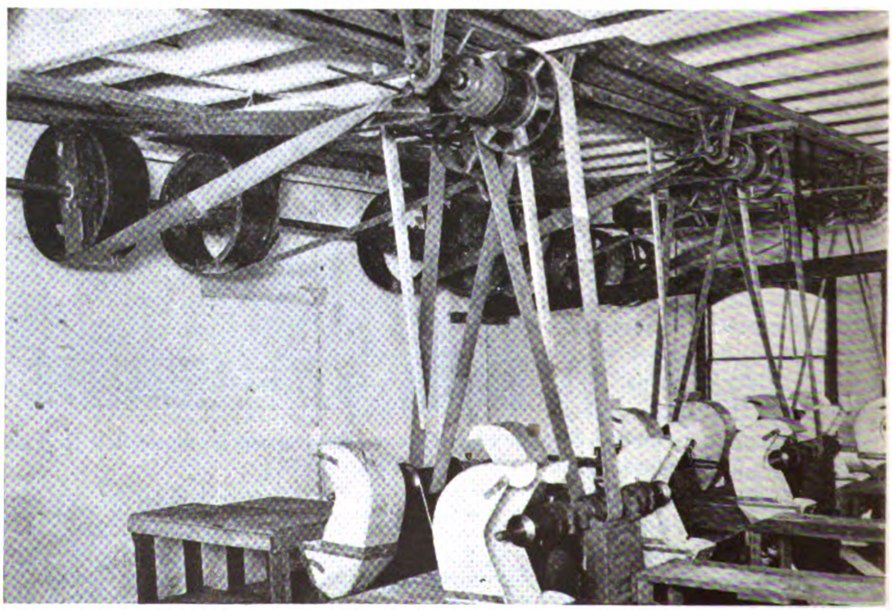
In some cases, individual drive was installed because other plants were making the change and without any careful analysis as to whether it was the most advantageous or economical. The high cost of making the change was probably the greatest deterrent to more widespread adoption of individual drive. New installations in many lines of industry were quite generally made with individual drive.

Within the past few years industrial operating men have begun to study and analyze their power transmission problems. The electric motor is becoming generally accepted as the logical and most economical driving unit. One man interviewed believes, however, that the steam engine will return as the driving unit in certain industries, such as in paper manufacture, where low-pressure steam is used in the process. Nevertheless, few industries dispute the advantage of the motor. The question now is, How can it be used to the best advantage?

Several of these factors which are responsible for the new attitude toward the method of applying the motor to its load are mentioned here and will be discussed more fully later in the article. For example, the increasing use of ball and roller bearings on lineshafts has decreased the friction loss and removed this objection to lineshaft drives. Wide publication of the investigations of The Leather Belting Exchange in their research work has shown industry the best methods of using leather belt, and pointed out its advantages and economy. Also, tests made under the supervision of this Exchange have indicated to the belt manufacturer methods whereby he has improved his product. Manufacturers of fabric base and rubber belts have likewise improved their product. Also, the series of articles by Robert W. Drake, Electrical Engineer, McCormick Works, International Harvester Company, Chicago, Ill., entitled, "When to Use Group and Individual Drive," which appeared in the February, March, and April, 1924, issues of INDUSTRIAL ENGINEER, and of which upwards of 70,000 reprints were distributed in industry, have set industrial men to thinking that the decision on whether group or individual drive should be installed should be based upon an analysis of the drive and the problems connected with it. In addition, during the past several years, there have been added a number of mechanical devices, such as silent chains, clutches, flexible couplings, speed reducers, variable-speed transmissions, silent gears, short-center belt drives, and other devices for connecting the motor to its load. Added types or improvement to a number of these have been announced within the past year. All of these factors have tended to make both group and individual drive more reliable. Practically every application of a motor to its machine now has pulleys, a belt, lineshaft, sprockets, chains, gears, flexible couplings, speed reducers, or other mechanical elements introduced between the motor and its load.

When operating executives consider the extent of the use of power in industry, they will appreciate the importance and large total saving which could be made through a small economy in the use of power. It has been estimated through recent surveys that industrial plants are now using about 23,552,665 horsepower, which is applied through some 1,936,114 motors. The types of drive used in connection with these motors are divided approximately as follows: belts, 990,312; chains, 101,181; and direct, that is, through couplings, gears, speed reducers, and so on, 835,699. The trend of future analysis will be watched with considerable interest by industrial men.

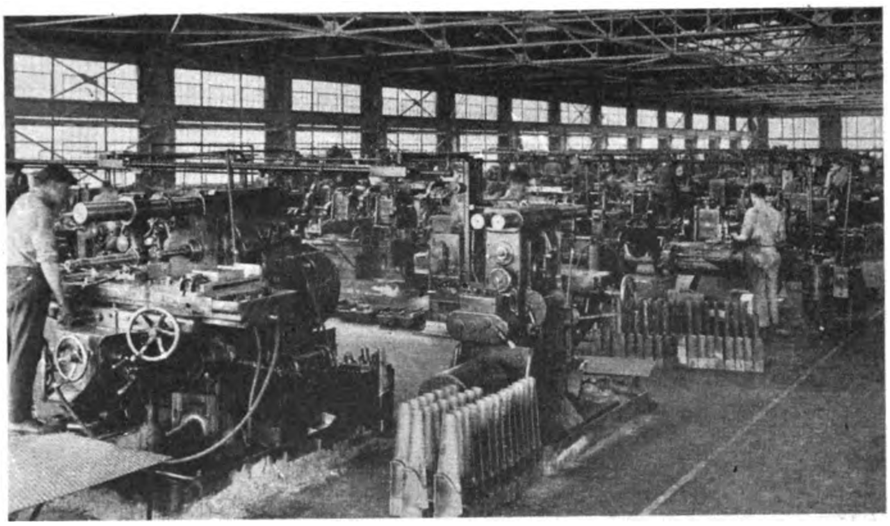
In this plating plant the buffing heads are driven from a Daggett ball-bearing, loose-pulley countershaft.



The present trends in power transmission will be discussed under the various sub-headings of the different auxiliary equipment used in connecting the motor to its load.

Group or Individual Drives—As stated before, the day of the long, heavy lineshaft is past. Also, there seems to be a more general tendency not to go to the extreme and make a whole plant individually driven, which results in a better balance between group and individual drives, according to the use or service conditions surrounding the installation. For example, in the woodworking department of plants, machines are commonly individually motorized. Some of the reasons for this are that woodworking machines are operated at high speed (often a frequency changer is used to increase the motor speed) and so the motor can be connected directly to the shaft of the machine, or with comparatively little increase or reduction of speed through a belt or other type of transmission. Also, the machines are usually widely separated to give floor storage space and seldom positioned in a line. In addition, one or more machines may be idle for a considerable period. All of these reasons favor the individual motor-driven unit.

On the other hand, where machines are alike and operate as a group and in a straight line and where the majority or none are operating at any one time, as in a battery of screw machines, lathes, milling machines, and so on, group drive through a lineshaft has economical operating advantages which should be considered. Some of these advantages



This is a typical example of a machine shop with individual drive.
This illustration was taken in one of the plants of the Westinghouse Electric & Mfg. Co.

are: The horsepower rating of the single motor on the group is much less, commonly $\frac{1}{5}$ to $\frac{1}{3}$ of the total corresponding rating of the motors on individually-driven machines, which gives more economical operation of the motor and a lower installation cost. Also, the machines are grouped and the lineshaft can be short, usually.

Where production layout demands that machines in small groups be placed out of line as in the so-called "unit production" plan in automobile plants, it is not always feasible to use a lineshaft. Also, flexibility of operation is of great importance in such cases and so individual drives are often used.

It is easily appreciated that any discussion of the type of drive on each machine or group of machines is an individual problem which should be determined by a study of the operating conditions, such as: relation to other machines, continuous or intermittent operation, relation of starting load to running load, operating flexibility required, original and operating cost, probable maintenance requirements, and other factors, which cannot be taken up at length in this article.

Lineshafts—In group drives instead of placing as many machines as possible in a single large group, the more general practice today is to subdivide these machines into numerous small groups of approximately uniform size. In different plants visited during the past year, it was the practice to standardize for each group the size of the motor, the lineshaft diameter and speed, and, as nearly as possible, belt widths and pulley sizes. The standard sizes adopted for the motors for each group varied with the operating conditions in these plants. In a few plants handling light work and using comparatively small machines, the groups were standardized to 15-hp. motors and in others to 20-hp. motors. Motor standards of 25 hp. and 35 hp. were used in other plants with heavier machines. One large plant with a wide variation of light and heavy work had three standard size groups driven by 25-, 50-, and 75-hp. motors, respectively.

Standardizing of the group size and speed requires fewer spare motors. Speed is standardized by making all driving pulleys on the shaft of the same diameter and putting on each motor a pulley which will give the proper reduction. Whenever a motor is changed the belt will fit on the new one because these pulleys are standardized. The men in each shop visited took pride in stating how quickly they could change a motor.

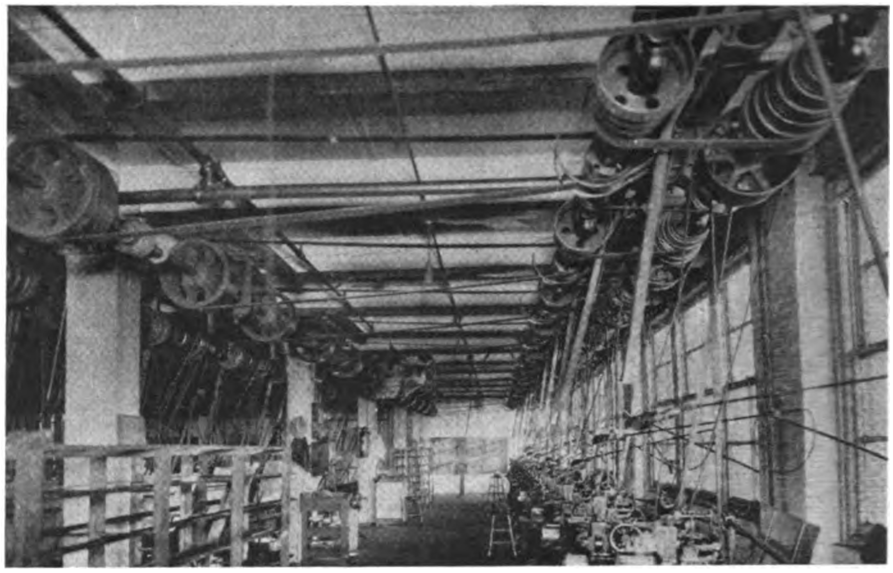
One Midwestern mill supply house reports that practically all the lineshafting sold is either $2\frac{1}{16}$, $2\frac{3}{16}$, $2\frac{5}{16}$, or $2\frac{7}{16}$ in. in diameter, which is a fair indication of the comparatively small size of the group drive today. Some shafting below 2 in. in diameter is sold to the tailor shops and other light manufacturing plants. Comparatively little call is made for shafting over 3 in. in diameter and this is largely for replacement or addition to existing lines.

With the increasing use of ball, roller and tapered-roller bearings for lineshafts, the compression type of coupling is becoming more generally used than flange couplings. This is because compression couplings are much more easily removed when it is necessary to slip bearings on or off over the end of the shaft.

Many new industrial plants are simplifying the problems that are incidental to the erection and shifting of lineshafts by the use of special steel shapes for supporting the shaft. These shapes of the Midwest (Midwest Steel & Supply Co.) type are inserted in the forms in concrete buildings before the concrete is poured and the stringers, which are also of special steel shapes, are attached to these inserts. When a building is constructed these inserts are placed at convenient distances apart throughout the entire ceiling so that a lineshaft may be easily erected anywhere. Because of changes in production demands the machinery and the shafting are shifted frequently in many plants and such construction simplifies making the change. The use of special steel shapes is not confined to concrete buildings and to new construction, however. In many old steel frame or mill-type industrial buildings these shapes are also used as stringers and footings. Because wood is less expensive in first cost and is universally accessible, it is perhaps more widely used for supporting shafting, however.

Industrial men are beginning to realize more clearly the importance of substantial supports for the lineshaft as well as the proper alignment and frequent re-alignment. Departments which have this work to do are keeping their forces employed steadily on general plant maintenance work so that they have better trained men for these jobs when called upon to shift machinery or a shaft on short notice. Trouble in many cases is no doubt attributable to the use of low-grade workmen in the erection and installation of the shafts and bearings.

Bearings—One of the most important steps toward the modernization of lineshaft drives has been the development of special hanger boxes with ball, roller, or tapered-roller bearings for use on lineshafts. These are of two general types: one in which the hanger box and hangers are specially built as a unit, and another, commonly known as the dumb-bell type, which is now available with any of the three types of bearings. This dumb-bell type is made to fit the various standard types of hangers and replaces the old hanger box. Some of the well-known types of so-called anti-friction bearings which have been put into hanger



Screw machines are a type of equipment which is well adapted to group drives.

In this case a battery of screw machines at the Addressograph Co., Chicago, Ill., is operated from a group drive. The mainshaft is driven by a motor through a Link-Belt silent chain. The lineshaft bearings are all Dodge-Timken.

boxes for power transmission work are: Chapman, Daggett, Dodge-Timken, Hyatt, Woods-Fafnir, and SKF. Some of these have been on the market for a number of years and have well demonstrated the advantages claimed for such use of anti-friction bearings. Others have been announced within the past year or two and additional lineshaft bearings are under process of development.

Manufacturers of these bearings have issued statements of tests which indicate a large saving in friction loss through their use. Another important advantage, in addition to the reduction of the friction loss, is that they need infrequent lubricating attention in contrast to the older type of bearing which required attention every day, or oftener, and in many cases failed or caused trouble through neglect for a short time only. These bearings require attention approximately only from one to four times a year, depending upon the service conditions. It is stated that in general these bearings suffer more from over-lubrication than from under lubrication. This is especially true where the lubricant, particularly grease, is forced in and the bearing filled under pressure. Lubrication problems, however, will be discussed later in this article as well as in the article on page 482.

A large proportion of new installations of lineshafts have bearings of the anti-friction type. In many other cases, plants are gradually modernizing their lineshafts by replacing their old bearings with the newer type whenever the old bearings cause trouble, or when the shaft is shifted to a new location. One large manufacturing plant in Chicago has followed this practice of replacing all troublesome bearings with new anti-friction bearings and discarding all old bearings on the entire shaft whenever it is moved, until practically the entire plant, containing several thousand bearings, is so equipped. This is a typical example of what is being done in many other industrial plants.

With the use of these anti-friction bearings many plants have speeded up their lineshafts until 500 r.p.m. is not at all uncommon, particularly on grinding or buffing operations. Also, in numerous instances where these bearings are used, the motor has been connected on to the end of the lineshaft through a flexible coupling and is operated at the motor speed, which in one case was 1,150 r.p.m.

The installation of these new bearings has emphasized to industrial men, the importance of correct alignment. A representative of one of these bearing companies states that in many instances when he calls at an industrial plant to supervise the installation of the new bearings, no one in the plant remembers when the shaft alignment was checked last. The new installation gives an opportunity to call attention to the necessity of alignment, so that many industrial plants are now making regular provision for such checks. For example, one Ohio plant checks the alignment of all shafts during the two weeks' shutdown period each summer. Other plants check up alignment at 2-year intervals.

Bearing trouble is probably the most common cause of plant stoppage, and many improvements have been made by manufacturers of machines, motors, and other industrial equipment, either by the adoption of anti-friction bearings or through the improvement of the existing bearings and better provision for their lubrication. Many interesting experiences with the use of such bearings in motors, particularly on cranes, have been reported in previous issues of INDUSTRIAL ENGINEER. This reduction of friction, both in the motor and on all rotating parts of the driven machine, has done much to improve the efficiency of power drives.

An unusual type of bearing, brought out within the past few years, is the Goodrich cutless rubber bearing, which is designed for use under water, particularly in paper mills.

Belts—Considerable work has been done by The Leather Belting Exchange through its research activities and educational work among the users of leather belts on the use of belts, how to take care of them, operating considerations, and other factors. One of the important results of these campaigns has been the wider use of cemented endless belts in industry. A large number of factories have adopted the practice of making all leather drive belts over 6 in. in width endless. This has been a very important factor in obtaining smooth power transmission. Although fasteners work satisfactorily, if put on properly, in many cases, too little attention has been given to their installation. Cementing a belt is a longer and somewhat more difficult job and requires greater attention. Also, the belt is held in position on the pulleys while it is cemented. This tends to hold it in the proper position and alignment. Smaller leather belts are commonly fastened by means of Alligator, Clipper, Detroit, or some of the other types of flexible lacings in which a metallic hinge is placed in the end of each belt and the two ends connected with a pin. A millwrighting contractor recently stated that during the past year he had been required in only one instance to use rawhide belt lacings and these were on hand-shifted belt drives, over step-cone pulleys. One of the important reasons for the popularity of the metallic lacings is the ease and

quickness with which they may be applied. Another practice in belt drive which has caused considerable argument among old-time industrial men has been whether the grain or flesh side of the belt should run next to the pulley. Tests have shown that the grain side transmits considerably more power, particularly as soon as the belt is broken in.

One place where practically every industrial plant still has an opportunity to modernize its application of the belt drive in the transmission of power is by the use of higher belt speeds. Many plants are operating belts at speeds not over 2,500 f.p.m., whereas they could be operated much more efficiently at 3,500 to 4,000, or even 4,500 f.p.m. Tests made by The Leather Belting Exchange have shown that the maximum operating speed of a leather belt is approximately 8,000 f.p.m. Increasing the belt speed is one of the easiest and simplest methods of getting more out of the belt drive. This is well recognized by many industrial men who solve many of their belt drive problems by increasing the pulley diameters, while maintaining the same ratios, and so increase the belt speed. Since horsepower is a factor of speed and tension, the belt at the new speed will easily pull a load which, under former speed conditions, was virtually an overload. Leather belts are receiving much more care today in industrial plants and are being cleaned, degreased, recemented, and in many cases rebuilt within the industrial plant. In this way, their life is almost doubled.

Due to the increased cost of floor space, or increased demands for space in industrial plant, considerable attention has been given to the use of short-center or gravity-idler belt drives, such as the Belt Slacker, Lenix and Pulmax drives, U. G. Automatic Belt Contactor, Medart Belt Adjuster, and others. These drives wrap the belt on the driving pulley and so increase the arc of contact with a short belt, whereas under the old practice, it was always necessary to have a long center distance between pulleys with high reduction ratio. These short-center belt drives necessitate using cemented endless belts and some belt manufacturers, on account of the reverse bending of the belt under the gravity idler, have recently developed especially pliable belts for such use.

Rubber and fabric-base belts have a wide use, particularly under certain operating conditions. For example, rubber belts are commonly used for very wet service conditions. Industrial men are realizing that a great deal of attention must be given to the joining of rubber and fabric-base belts. There are a large number of plates, hooks, clamps, and other connectors which are used for this purpose.

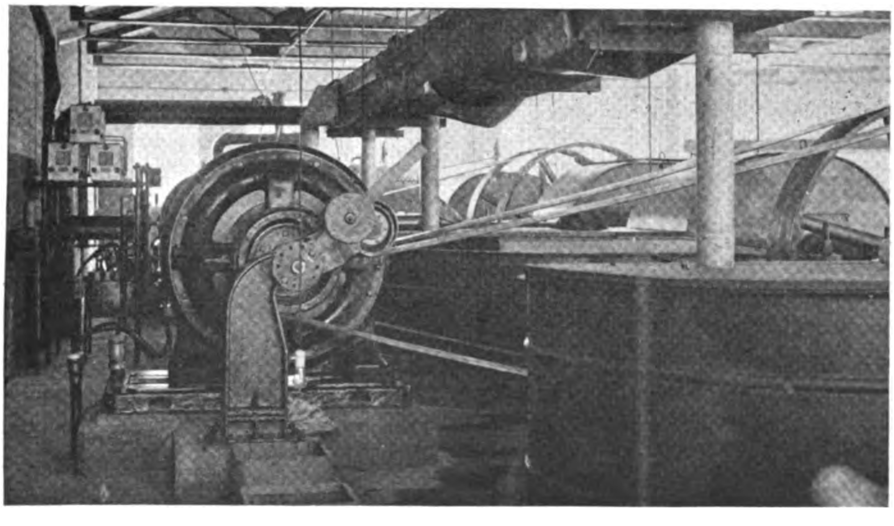
Considerable experimental work has been done, and several installations have been made, using steel belts for transmitting power. These, however, are not used extensively.

A comparatively recent development is the Texrope (Allis-Chalmers Mfg. Co.) drive which consists of fabric base belts of triangular cross-section which fit into V-grooves on the driving and driven pulleys. A considerable number of these drives are being tried out in various industries and the experience with them is being watched with a great deal of interest. A Texrope drive installation is shown in an accompanying illustration.

Chains—It has been estimated through an industrial survey that about 5 per cent of the motors in industrial plants are connected to the load with chain drives. The use of a chain to connect the motor to its lineshaft is very common because this gives a short-center drive with a positive speed reduction ratio. A recently installed lineshaft drive of this type is shown in an accompanying illustration. One of the reasons for the widespread use of chain drives is their adaptability through a wide range of horsepower and speed ratings. Users are becoming more accustomed to taking into account the service conditions and consulting the manufacturer when considering a chain drive. Excessive and repeated overloading (particularly if a shock load) causes a mechanical strain on the elements of the chain, which, if continued, will have its effect. With chain drives and all other elements of power transmission equipment, it is necessary to use service factors in determining the size or rating of the mechanical unit in order to compensate for unusual operating conditions. The use of roller chain for power transmission, particularly in drives, is increasing.

With chain drives and other positive connections of a motor to its load, it is frequently necessary to provide a safety link so that in case the machine is stopped suddenly, the link will break before some more expensive part of the equipment breaks. These breaking links, or safety links, are usually fitted into the sprockets of silent chains. This link serves as a mechanical fuse to protect the equipment the same as the electrical fuse protects the motor. Industrial men who have tried to develop these safety links in other types of drives and in machine mechanisms are strong believers in the advantages and decreased maintenance accruing from them.

Silent chains up to 10 hp. are being stocked to some extent in distributing centers over the United States so that immediate delivery may be obtained. These are kept in stock only in certain reduction ratios which give the more commonly used operat-



Gravity idlers are frequently used to maintain the proper tension on belts, particularly where there is considerable difference in the diameters of the driving and driven pulleys.

In this instance, a 150-hp. 485-r.p.m. slip-ring motor with extended shaft is used in connection with Lenix drives to operate beaters in pairs in a paper mill. Lenix and other types of short-center drives save considerable floor space in the modernization of industrial plants.

ing speeds when connected with standard speed motors.

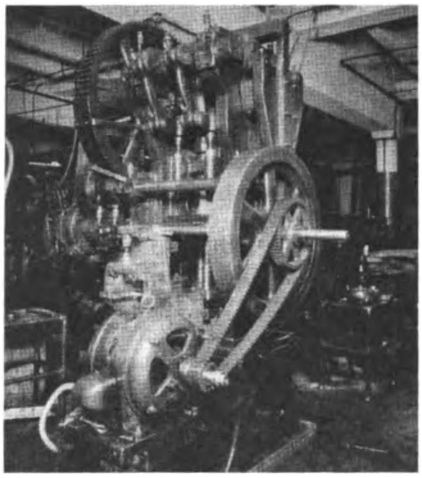
Gears—Open-gear drives have always presented one of the troublesome lubricating and operating problems in industrial plants. Many of these have been supplanted with silent chain because the latter give a positive reduction ratio. However, the tendency, wherever it is desirable to use gears, is to enclose them and if possible provide for a bath or splash system of lubrication.

Much use is being made of the so-called silent or non-metallic gear, particularly those made of Bakelite composition and marketed under various trade names, such as Fibroc, Formica, Micarta, Textolite, Fabroil, and so on. Gears of these materials have done much to reduce wear and prevent the noise which have always been considered as unavoidable with gear drives. During the past year a special Fibroc gear material has been placed on the market which is impregnated with graphite, to give it, according to the manufacturer, self-lubricating qualities.

Speed Reducers—Due to the increase in operating economy of the high-speed induction motor, which operates at a speed several times that used for the driving shaft of many machines, it was necessary to provide some means of obtaining the large reduction in speed in a closely-coupled drive. For a considerable number of years both the worm and gear types of speed reducers have been gaining the attention of industrial users. These reducers can be used either singly or in combination to make extremely high reduction ratios.

Some of the types of gear reducers are made in ratings up to 250 hp., although other manufacturers set 100 or 150 hp. as their maximum size. Two types of gear reducers, the Lipe and the Albaugh-Dover are provided with anti-friction bearings. Also, several manufacturers have redesigned their worm gears to provide them with ball or roller and also improved plain bearings. In some other cases the angle of the worm and the material of which it is made has been improved. A double-reduction worm gear has been brought out comparatively recently by the DeLaval Steam Turbine Co., which enables a much higher reduction ratio to be obtained through worm gearing. In this reduction unit, special oil-circulating and lubricating features are incorporated. Additional information regarding reducers will be given in the accompanying article beginning on page 474.

During recent years considerable attention has been given to the herringbone speed reduction unit, and there is a great deal of competition in the application of this type, particularly from 50 hp. and up to the capacity of the planetary, and non-planetary spur gear reduction units. Herringbone gear units are made in single- and double-reduction units and are coming into very common use in large sizes for transmitting upwards of several thousand horsepower, as in steel mill drives, and are used almost altogether above 150 to 250 hp.



On some machines, particularly where a motor of more than 5-hp. rating is required, individual drive often affords important operating advantages.

Operating men are carefully studying the power transmission problems in connection with their machines to determine the best type of drive for each. This Bliss punch press is connected to the motor by a 10-hp. Link-Belt silent chain. Press drives, because of the shock load, require special attention to the rating of the drive.

Although users of speed reducers are becoming much more familiar with them and with the requirements of their specification, however, in many cases the user neglects to consider that the amount of power to be transmitted at the low speed is the most important factor in the determination of the proper size of reducer. Also, that unusually severe service conditions necessitate the use of a service factor in determining the rating of the unit.

Flexible Couplings—Another important mechanical element of power transmission equipment is the flexible coupling particularly for high-speed operation. There is a wide range of types and kinds of flexible couplings, many of which were described in articles on flexible couplings in the November, and December, 1923, issues of INDUSTRIAL ENGINEER. The flexible coupling is used on the end of the motor shaft, speed reducer shaft, or other driven units, to connect the shafts and take care of any slight misalignment. For example, while every effort should be made to line up a motor and a speed reducer, centrifugal pump, or other such machines, perfect alignment is seldom obtained, and a very slight misalignment which may be hardly discernible when testing the alignment would cause considerable trouble at high operating speed, if the shafts were connected by a solid coupling. In some cases operating men consider a flexible coupling as a universal joint and do not use sufficient care in the alignment to prevent operating troubles. Through past experience and education many users are becoming more acquainted with the proper application of such units, the necessity of applying service factors when selecting units for particularly severe operating conditions, and the importance of obtaining as near perfect alignment as it is possible to obtain, with foundations or other mountings sufficiently substantial to retain the alignment as long as possible. Operating men are also finding that alignment needs frequent checking.

Some manufacturers are stocking flexible couplings in fractional horsepower sizes and up to 10-hp. rating in mill supply houses and in various distributing centers. Flexible couplings are manufactured in capacities ranging from fractional horsepower up to several thousand horsepower, for steel mill drives. Special units are made for extremely high speed operation, which requires more perfect balancing of the elements of the couplings, and also for installations where a noticeable lack of alignment is necessary, and is compensated for by double units. A recent development is the use of a special flange built on a coupling on which the circumference is used as a brake wheel. One of these is shown in an accompanying illustration.

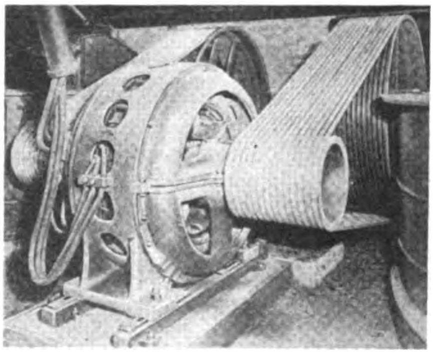
Clutches—A recent development in clutches and cutoff couplings has been brought out by the Edgemont Machine Co., through the addition of anti-friction bearings in the couplings. Many industrial men have a preference toward putting clutches on machines rather than on the line-shafts, although this is not at all universal. Some industrial plants have preferred to put the clutch on

the lineshaft as in that way the countershaft is eliminated. In general, there has not been as much mechanical development on clutches during the past few years as there has been in the case of bearings, flexible couplings, and other equipment. With the modern tendency toward high-speed operation, clutches are subject to very severe operating service.

Variable Speed Transmissions—Variable speed is obtained generally either electrically, mechanically, or hydraulically. Control of variable-speed motors in practically all cases gives the increments in speed in definite steps and seldom gives a minimum speed less than one-half of full speed. In many cases, only a few steps or variations are obtainable. Variable-speed motors were first applied to direct drive on machines and some difficulty resulted in many cases due to neglect to consider that usually the greatest power requirements, as on a lathe for example, were found at the lowest speed, where the motor delivered the least power. This difficulty may be corrected by providing increased motor capacity. Variable mechanical power reduction is obtained either by means of a shifting belt on a pair of cone pulleys as in the Moore & White variable-speed transmission, or through shifting the diameter of a pair of V-faced pulleys driven by a V-belt as in the Reeves and the Lewellen variable-speed transmissions. With these units variation is obtained in very small increments over a considerable range of speed from slightly above to below the input speed.

Recently, the JFS, a new mechanical, variable-speed transformer, which is described in detail in the New Equipment section on page 498 of this issue, has been placed on the market. This is a device which gives a variable speed reduction.

Hydraulic speed reducers, such as the Hele-Shaw (American Engineering Co.), Oilgear (The Oilgear Co.) and the Waterbury (Waterbury Tool Co.) which is also described on page 497 of this issue, consist of a pair of hydraulic pumps, turbines, or motors, so connected that the unit operating at the intake speed delivers a variable amount of liquid, usually oil, to the other unit, which is thus driven at a speed correspond-



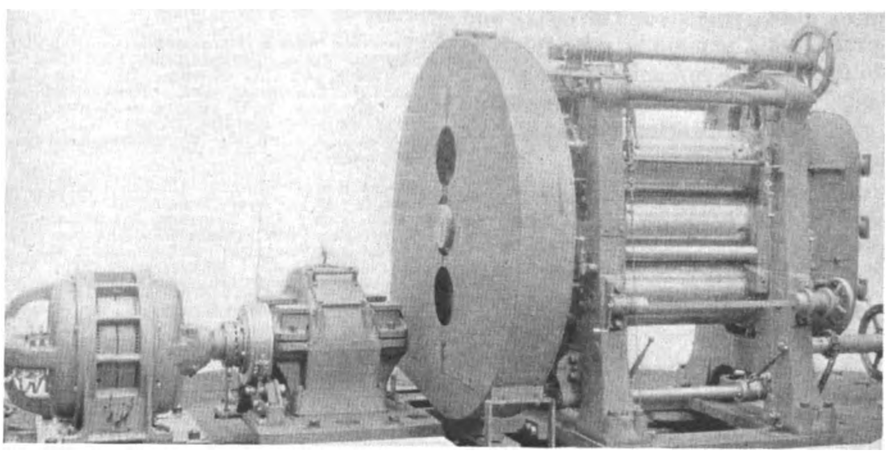
An example of a Texrope drive in a paper mill.

In this case two Texrope drives on 84-in. centers are operated from a 250 hp., 440-r.p.m., type ANY Allis-Chalmers motor to drive two pulp beaters at 122 r.p.m. The Texrope drive is a V-shaped endless, textile base belt made up in individual strands, which fit in grooved pulleys.

ing to the amount of liquid which it receives.

Both mechanical and hydraulic variable-speed transmissions permit very slight variations of speed over a considerable range. In addition, the hydraulic units permit a variation from zero, in most cases, up to the input speed in either direction; that is, they are reversible. Variable-speed devices are becoming widely used in textile work where the speed of operation depends upon the weight or grade of material manufactured, conditions of humidity, quality, and other factors. Another new tendency in these units is to use them to start up machines at slow speed and gradually work up to operating speed. This is particularly noticeable in the automobile conveyor assembly lines which are driven slowly at first and the speed gradually increased as the men become "warmed up" to their task and also, in textile mills, where the machines are started slowly to prevent breakage of thread.

Lubrication—No doubt one of the most noticeable steps toward the modernization of power drives is the change in knowledge of, and attitude toward, lubrication. Much of this is due to the widespread use of the automobile and the general realization of and experience with the importance of its lubrication as well as the improvement in lubricants and greater knowledge of their purpose and application, which has been obtained through the study of automobile bearings and lubricants, by the manufacturers of both. Not many years ago it was the practice in many plants to hire a man at the gate and put him to work oiling equipment, with comparatively little instruction or supervision. Today, with anti-friction and other improved bearings, lubrication receives much less frequent but more careful attention. This new attitude is well illustrated by the practice of the management of a Michigan factory manufacturing forgings. In this plant, an experienced mechanic, at corresponding wages, does all of the oiling, even to the machines, and the management considers the difference in wages above what is commonly paid an oiler as well spent because of the very noticeable decrease in bearing troubles and maintenance cost, in addition to the saving in lubricants and freedom from interruptions. Industrial men are learning that the selection of the proper lubricant and its application are of the utmost importance. In the opinion of some industrial engineers improvements in bearings and methods of lubrication, which have been developed together, have been the outstanding features in the bet-



This is an example of the use of a brake coupling on a three-roll calender.

Here one half of the Francke coupling is mounted on the motor shaft in the usual way and the other half is bolted against the brake wheel. This brake wheel is fastened on the end of the pinion shaft of the reduction gear which, in turn, drives a second gear reduction connected to the three-roll calender. This coupling is on a 690-r.p.m., 50-hp. motor.

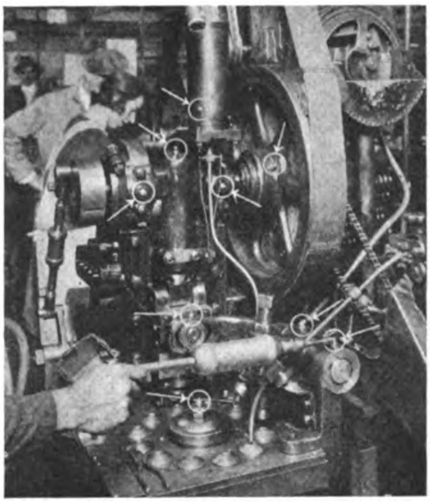
terment and modernization of power transmission equipment. Increased operating speeds have made necessary these improvements in bearings and their lubrication in motors, hanger boxes, and practically all types of machines.

Considerable attention is being given to the application of lubricants by means of the portable pressure lubricating devices such as the Adams, Alemite, Alemite-Zerk and Dot systems, as well as a number of pressure lubricating devices which are built into the machine, such as Bowen, Detroit, Keystone, Madison-Kipp and McCord, which were described in the article entitled, "Equipment Used for Applying Lubricants," on page 213 of the May, 1926, issue of INDUSTRIAL ENGINEER. Some of these lubricating devices are used for oil and others for grease lubrication. Safety to the oiler and the use of pressure, which forces the lubricant into the bearing, are the chief advantages claimed for these types of lubricating devices. Also, where a machine is fitted with any of the positive built-in types of lubricators, all bearings are lubricated simultaneously and none is overlooked. The lubrication of many bearings in industrial plants is a hazardous operation for the oiler and accidents are very likely to be serious. One large industrial plant in Detroit states that it has practically eliminated accidents to the oilers through the introduction of a pressure system of lubrication, whereas previously the hospital contained at all times one or more oilers who had been injured.

Because of the danger of overfilling anti-friction bearings Fairbanks-Morse Co. has brought out a ball-bearing grease for their motors in collapsible, soft-metal tubes of various sizes, each of which contains the correct amount of grease for a special size of bearing.

One of the most difficult lubrication problems in industrial plants is in connection with loose pulleys on mainshafts or countershafts. As a result, many men are using ball-bearing countershafts, such as the Daggett (Chicago Pulley & Shafting Co.), in which the tight and loose pulleys both operate on ball bearings in the hubs of the pulleys because ball bearings are easier to lubricate and require less frequent attention. One Chicago concern, for example, purchases all machines without countershafts and obtains a ball-bearing countershaft separately. On existing installations, the countershafts, as soon as they cause excessive trouble, are replaced.

In the same way, many industrial plants are using the Gast oiling machine (Standard Pressed Steel Co.), which consists of a special oil chamber with a chain oiler that fits over a bushing in the hub of the pulley and supplies the lubricant to the bearing as the shaft revolves.



Modern factory practice gives close attention to lubrication.

In this case the bearings on a special press are fitted for the Alemite-Zerk system of lubrication. The circle shows the fittings on the bearings which are lubricated from the pressure gun in the foreground.

Within the past year the Dodge Mfg. Corp., Mishawaka, Ind., has announced a roller-bearing loose pulley. This consists of a cast-iron or Oneida steel pulley provided with an extra large bore to receive a Dodge-Timken roller bearing.

One of the most noticeable features in connection with power transmission problems in present-day industrial plants is that a great deal of attention is being given by the operating executives to investigating new types of equipment much more thoroughly than formerly, and purchasing them on a quality, reliability, and low-maintenance-cost basis, when plans are being made for the modernization of the power drive equipment.

EDITORS' NOTE. Acknowledgment is made to the following companies for illustrations and information used in the preparation of this article:

General Power Transmission — Bond Foundry & Machine Co., Manheim, Lancaster Co., Pa.; Chicago Pulley & Shafting Co., Chicago, Ill.; Dodge Manufacturing Corp., Mishawaka, Ind.; Falls Clutch & Machinery Co., Cuyahoga Falls, Ohio; The Hill Clutch Machine & Foundry Co., Cleveland, Ohio; Medart Co., St. Louis, Mo.; T. B. Wood's Sons Co., Chambersburg, Pa.

Belts, Belt Drives and Supplies — Alexander Bros., Philadelphia, Pa.; Allis-Chalmers Mfg. Co. (Texrope), Milwaukee, Wis.; Bird Machine Co., Pulmax Drive Division, So. Walpole, Mass.; Birdsboro Steel Foundry & Machine Co. (Jackson Lacer), Birdsboro, Pa.; The Bristol Co. (Steel Lacings), Waterbury, Conn.; Chicago Belting Co., Chicago, Ill.; Chicago Flexible Shafting Co. (Alligator Lacing), Chicago, Ill.; Clipper Belt Lacer Co., Grand Rapids, Mich.; Detroit Belt Lacer Co., Detroit, Mich.; The Diamond Rubber Co., Akron, Ohio; R. & J. Dick Co., Inc., Passaic, N. J.; B. F. Goodrich Rubber Co., Akron, Ohio; Goodyear Tire & Rubber Co., Akron, Ohio; Graton & Knight Mfg. Co., Worcester, Mass.; The Medart Co. (Belt Adjuster), St. Louis, Mo.; Harry M. Perry (Belt Slacker), Los Angeles, Calif.; The Republic Rubber Co., Youngstown, Ohio; J. E. Rhoads & Sons, Wilmington, Del.; Chas. H. Schieren Co., New York, N. Y.; F. L. Smidth & Co. (Lenix Drive), New York, N. Y.; Stanley Belting Corp., Chicago, Ill.; U. S. Rubber Co., New York, N. Y.; Victor Balata & Textile Belting Co., New York, N. Y.; I. B. Williams & Sons, Dover, N. H.

Chain Drives — American High Speed Chain Co., Indianapolis, Ind.; Baldwin Chain & Mfg. Co., Worcester, Mass.; Boston Gear Works Sales Co., Norfolk Downs, Mass.; Chain Belt Co., Milwaukee, Wis.; Diamond Chain & Mfg. Co., Indianapolis, Ind.; Link-Belt Co., Chicago, Ill.; Morse Chain Co., Ithaca, N. Y.; Ramsey Chain Co., Albany, N. Y.; and Whitney Mfg. Co., Hartford, Conn.

Flexible Couplings—The Bartlett Hayward Co., Baltimore, Md.; The Clark Controller Co., Cleveland, Ohio; The Falk Corp., Milwaukee, Wis.; R. D. Nuttall Co., Pittsburgh, Pa.; Poole Engineering Co., Baltimore, Md.; and Smith & Serrell, Newark, N. J.

Hanger Bearings—Chicago Pulley & Shafting Co. (Daggett) Chicago, Ill.; Dodge Manufacturing Corp., Mishawaka, Ind.; The Fafnir Bearing Co. New Britain, Conn.; Hyatt Roller Bearing Co., Newark, N. J.; Timken Roller Bearing Co., Canton, Ohio; The Transmission Ball Bearing Co., Inc. (Chapman) Buffalo, N. Y.; SKF Industries, Inc., New York, N. Y.; and T. B. Wood's Sons Co., Chambersburg, Pa.

Lubrication and Lubricating Devices—Adams Grease Gun Corp., New York, N. Y.; The Bassick Mfg. Co. (Alemite and Alemite-Zerk), Chicago, Ill.; Bowen Products Corp., Auburn Div., Auburn, N. Y.; Carr Fastener Co. (Dot), Cambridge, Mass.; Detroit Lubricator Co., Detroit, Mich.; Gits Bros. Mfg. Co., Chicago, Ill.; Kelly Lubricator Co., Syracuse, N. Y.; Keystone Lubricating Co., Philadelphia, Pa.; Knorr Lubricator Sales Co., Boston, Mass.; Madison-Kipp Corp., Madison, Wis.; McCord Radiator & Mfg. Co., Detroit, Mich.; Standard Oil Co. of Ind., Chicago, Ill.; The Texas Co., New York, N. Y.; and the Vacuum Oil Co., New York, N. Y.

Speed Reducers — Albaugh-Dover Mfg. Co., Chicago, Ill.; Boston Gear Works Sales Co., Norfolk Downs, Mass.; Cleveland Worm & Gear Co., Cleveland, Ohio; De Laval Steam Turbine Co., Trenton, N. J.; Falk Corp., Milwaukee, Wis.; Fawcus Machine Co., Pittsburgh, Pa.; Foote Bros. Gear & Machine Co., Chicago, Ill.; Wm. Ganschow Co., Chicago, Ill.; The Hill Clutch Machine & Foundry Co., Cleveland, Ohio; Horsburgh & Scott Co., Cleveland, Ohio; D. O. James Mfg. Co., Chicago, Ill.; W. A. Jones Foundry & Machine Co., Chicago, Ill.; R. D. Nuttall Co., Pittsburgh, Pa.; Philadelphia Gear Works, Philadelphia, Pa.; and Winfield H. Smith Co., Springville, N. Y.

Variable Speed Transmission—American Engineering Co., Philadelphia, Pa.; Columbia Vari-Speed Co., Chicago, Ill.; Lewellen Mfg. Co., Columbus, Ind.; Reeves Pulley Co., Columbus, Ind.; Moore & White Co., Philadelphia, Pa.; The Oilgear Co., Milwaukee, Wis.; and The Waterbury Tool Co., Waterbury, Conn.

Silent Gears—Chicago Rawhide Mfg. Co., Chicago, Ill.; Fibroc Insulation Co., Valparaiso, Ind.; The Formica Insulator Co., Cincinnati, Ohio; General Electric Co. (Fibroil and Textolite), Schenectady, N. Y.; and Westinghouse Electric & Mfg. Co. (Micarta), East Pittsburgh, Pa.

Miscellaneous — American Pulley Co., Philadelphia, Pa.; Conway Clutch Co., Cincinnati, Ohio; Edgemont Machine Co., Dayton, Ohio; B. F. Goodrich Rubber Co. (Cutless Bearings), Akron, Ohio; Midwest Steel & Supply Co.; The Rockwood Mfg. Co., Indianapolis, Ind.; and Twin Disc Clutch Co., Racine, Wis.

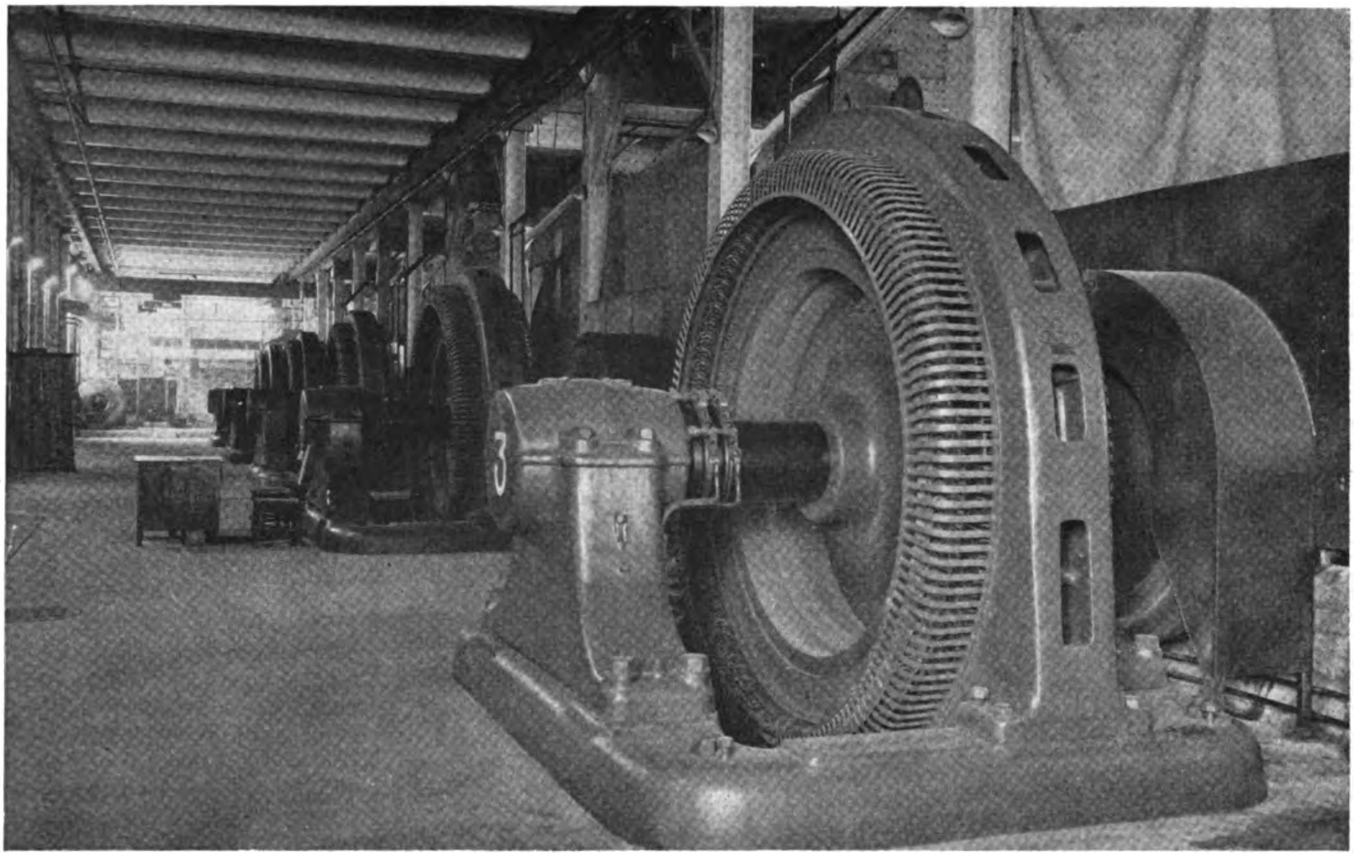


Fig. 1—The synchronous motor is beginning to come into its own.
Here are five of a row of seven General Electric, 2,400-hp., 2,200-volt, 240-r.p.m., synchronous motors driving magazine grinders in the paper mill of the St. Maurice Lumber Co.

Selection of Motors for Industrial Power Drives

including a discussion of the operating characteristics of the more common types, with special emphasis on the advantages of the synchronous motor

DURING the past 30 years the advance of science and technology has been so rapid that new discoveries and inventions are buried under an avalanche of still newer ones long before they have been properly assimilated into the life of the country. Our great need is for a constant synthesis, an incessantly repeated effort to bring together related parts of our rapidly growing knowledge into a well-knit unit suitable for concrete application.

It is my purpose here to picture briefly an ideal industrial unit considered from the electrical power standpoint. I shall consider the various requirements of industrial drives and from available equipment so select that the resultant whole may incorporate what must always be our ideal in industry—a maximum of what is desirable at a minimum of cost.

By PHILIP CHAPIN JONES
Electrical Engineer, The Goodyear Tire and Rubber Company, Inc., Akron, Ohio

In any ordinary large plant there is a distinct need for six types of motors. Obviously these six classifications are:

(1) Squirrel-cage induction motor.
(2) Wound-rotor induction motor.
(3) Direct-current shunt motor.
(4) Direct-current series motor.
(5) Direct-current compound wound motor.
(6) Synchronous motor.

Taken the country over, undoubtedly the vast majority of drives require merely an approximately constant-speed motor, easily stopped and started, but with no particularly abnormal starting or stopping torques. Arbitrarily, a normal starting torque could be defined as not over 50 per cent of the full-load torque. In this realm the squirrel-cage induction motor reigns supreme, and is thus naturally the most widely used form of motor.

I will not attempt to describe this well-known type of motor but will point out a few of its characteristics. The synchronous speed of this type of motor is fixed, depending upon the frequency and number of poles. The actual speed is less than the synchronous speed by the amount of the slip. The ordinary squirrel-cage motor has a slip of 3 to 5 per cent from no-load to full-load.

The squirrel-cage motor does not develop as high a starting torque as some other types. Slow-speed squirrel-cage motors will develop about 125 per cent of full-load torque, while high-speed motors will deliver up to 250 per cent of full-load torque at start, provided full voltage is applied to the primary. This will require a current at starting from six to seven times full-load current, which in most cases will be objectionable for motors larger than 5 hp. Hence, starting at reduced voltage is necessary, which in turn reduces the starting torque in proportion to the

square of the voltage. The operating characteristics of a typical polyphase squirrel-cage induction motor are shown in Fig. 4. This curve together with those shown in Figs. 2, 5, 7, 8, 11, 12 and 15 are taken from "Principles of Electric Motors and Control" by Gordon Fox.

The efficiency of squirrel-cage motors is poor at low speeds but is better in the higher speeds. Also, it is better in the larger capacities than in the smaller. A 5-hp., 1,200-r.p.m. motor has a full-load efficiency of approximately 86 per cent, whereas a 50-hp. motor of the same speed has an efficiency of nearly 90 per cent. The efficiencies range from 80 per cent in the 5-hp., 360-r.p.m. size to 92 per cent in the 50-hp., 1,800-r.p.m. size. Full-load efficiency curves for squirrel-cage motors are shown in Fig. 5.

The power factor of a squirrel-cage motor is very low at light loads and is also low in the low-speed types. The power factor gradually improves as the load on the motor approaches its rating, and will range from about 79 per cent for a 5-hp., 900-r.p.m. motor and 89 per cent for a 5-hp., 1,800-r.p m. motor to 88 per cent for a 50-hp., 900-r.p.m. motor and to 93 per cent for a 50-hp., 1,800-r.p.m. motor. Power factor curves for squirrel-cage motors are shown in Fig. 6.

The squirrel-cage motor is excellently adapted for all classes of constant-speed drives which require moderate starting and running torques and where starting is infrequent. The great majority of fixed-speed drives fall in this class. Because of its lower first cost and simplicity, the squirrel-cage motor is generally preferred to the direct-current shunt motor for constant-speed duty. In many respects its characteristics are similar to those of the constant-speed shunt motor.

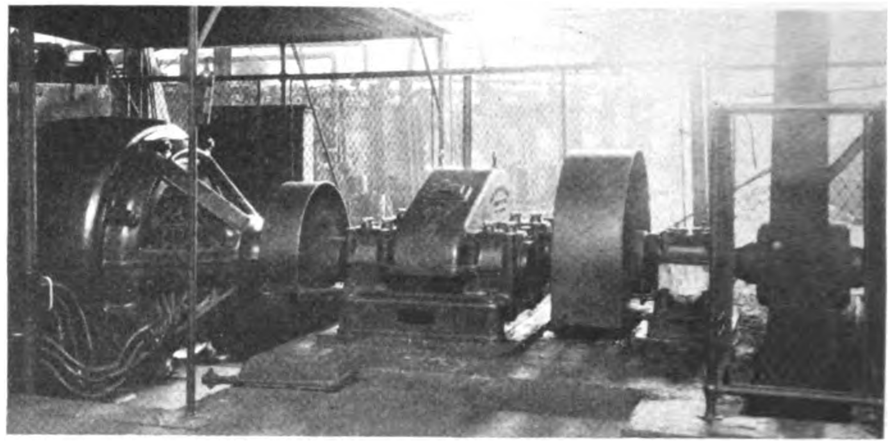


Fig. 3—The wound-rotor motor is unusually well adapted to drives that require flywheels.

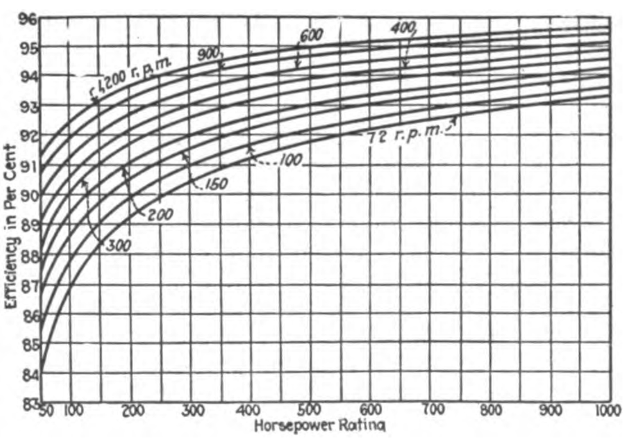
External resistance connected to the rotor winding makes the motor tend to slow up on the load peaks, thereby permitting the flywheel to carry the peak. After the peak passes, the induction motor speeds up the flywheel to its original speed. Hence, the flywheel carries the peak and there is no excessive peak power demand by the motor. This illustration shows a Westinghouse, wound-rotor motor connected through a speed reducer and flywheel to a steel mill drive.

To get away from the disadvantage of using reduced starting voltage and consequent reduced starting torque, double-winding, squirrel-cage motors have been developed. These have a high-resistance winding that is effective during starting, and a low-resistance winding that comes into play after the motor comes up to speed. These motors do not require starters and are sometimes called high-torque motors because they will develop a starting torque of 2 to 2½ times full-load torque with three times full-load current. They are a more recent development, but are fast becoming popular.

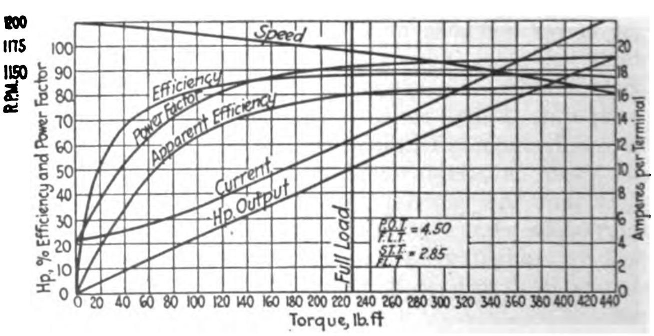
The polyphase, wound-rotor induction motor is similar in general characteristics to a shunt-wound, direct-current motor having a speed regulating resistance in the armature circuit. At starting it develops full-load torque with full-load current. Speed may be varied by cutting resistance in or out of the rotor circuit; the speed will, however, also be dependent upon the load on the motor. The power factor of the wound-rotor motor is similar to that of the squirrel-cage motor, but varies with the torque that is developed rather than the horsepower output. Its efficiency is about the same as that of the direct-current, shunt motor. Characteristic curves for a typical wound-rotor motor are shown in Fig. 9.

The wound-rotor motor is used where frequent starting duty or where high starting torque, or moderate starting torque combined with low current input, are desired. Because the operating characteristics of the wound-rotor motor with external resistance are very much like those of the compound wound or series, direct-current motor (except as to efficiency), it is sometimes used for the service to which these types are adapted. The wound-rotor motor is particularly adapted to loads having a flywheel to carry them over high peaks. It is widely used for cranes and hoists, shears, presses, elevators, and similar manipulating duty.

The direct-current, shunt motor is a constant-speed motor, having only



Figs. 2 and 4—At the left are shown full-load efficiency curves of synchronous motors operating at 100 per cent power factor. At the right are shown characteristic curves of a typical, squirrel-cage, induction motor.



Comparative Operating Characteristics of Common Types of Industrial Motors†

Type of Motor	Starting Torque	Starting Current	Maximum Torque	Can Speed Be Adjusted	Effect of Load on Speed	Power Factor	Efficiency
General-purpose squirrel cage	D	A	C	No	C	High speed-B Low speed-C	B
Wound rotor	B	D	D	Yes-C	C	B—	C
Synchronous	D*	C	B	No	A	Adjustable	Slow speed, large size-A High speed, small size-C
Shunt	C	C	C	Yes-A	B		B
Series	A	E	A	Yes-B	D		B
Compound	B	D	B	Yes-B	C		B

The grading of A, B, C, etc., in each case indicates the relative degree that a given characteristic is possessed by each type of motor. Thus A indicates best, highest, or most; B indicates second best or second highest; C third best, etc. For instance, A in starting torque column indicates that the series motor has the highest starting torque, whereas A in the starting current column indicates that the general-purpose, squirrel-cage motor has the highest starting current.

†This tabulation represents in a general way what can be expected of average designs of motors of the types listed, which are in common usage, and is not intended to cover motors that have been especially designed for specific applications.

*This rating is obtained by the synchronous motors described by the author and is higher than that obtained from older designs of synchronous motors.

a small variation from no-load to full-load. The starting torque of this motor is about 150 per cent of full-load torque with 150 per cent current input. It is able to exert a good starting torque, but only at the expense of a large starting current. This motor will exert a breakdown torque of about 3½ times full-load torque. Its efficiency is very good and remains so over a considerable range of load. As a constant-speed motor it meets the requirements of a large range of industrial applications. Its characteristics render it the best suited direct-current motor for the majority of constant-speed drives that do not require excessive starting torque nor have high-speed loads. Characteristic curves for a shunt motor are shown in Fig. 13.

By varying the resistance in series with its shunt field, the shunt motor becomes an excellent adjustable-speed motor. It is extensively used for individual drives where a selective range of speeds is desired with good regulation at any point. High efficiency, easy and exact manipulation, together with steady running make this type of motor very satisfactory for adjustable-speed drives. Motors of this type are extensively used in machine tool work.

The series motor is essentially a high-torque motor. At standstill the torque may be several times full-load torque. Heavy overloads can be handled with good commutation. The series motor will start a much heavier load than will the shunt motor, and will accelerate with less current input. Its efficiency, however, is somewhat lower than that of the shunt motor. It is not a constant-speed motor, for the speed is low on heavy loads and high on light loads. In fact, this motor will run away if the load becomes too light. Characteristic curves for a series motor are shown in Fig. 7.

The series motor is extensively used on cranes and hoists, steel mill auxiliary drives, small ventilating fans, in electric traction service, and the like. The character of the load should be such that it increases rapidly with the speed.

The characteristics of the compound-wound motor combine in varying degrees those found in the series and shunt motors. Its speed decreases with increase of load and the torque increases rapidly with addition of load. It develops a high torque per unit of starting current and has a heavier breakdown torque than the shunt motor. It is a fairly constant speed motor with excellent pulling power on heavy loads, combined with good starting power. The characteristics of a typical compound motor are shown in Fig. 15.

The compound-wound motor is used extensively for driving pumps, compressors, shears, presses, reciprocating tools, and the like, where irregular loads with severe peaks are encountered, together with a demand for fairly constant speed.

The types of motors just discussed cover all of the mechanical requirements of most drives, but the complete and successful application of electric motors to industrial uses requires consideration of the entire power system from the turbines to the driven machine. The majority of all industrial drives use induction motors, which results in a moderate or low lagging power factor on the plant power system. This poor

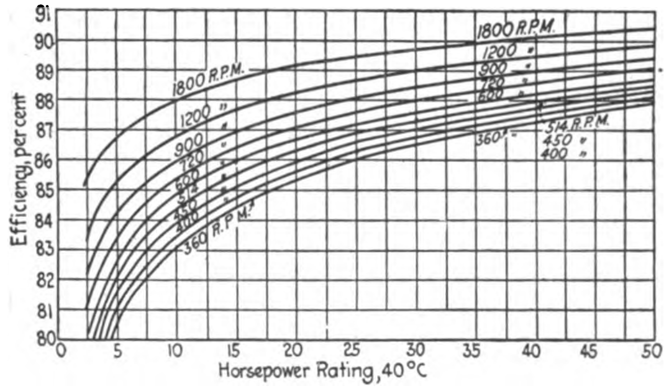


Fig. 5—Full-load efficiencies of 60-cycle, polyphase, squirrel cage, induction motors.

Efficiencies for motors of different horsepower and speed ratings are given. These curves together with those shown for Figs. 2, 4, 7, 8, 11, 12, and 15 are from "Principles of Electric Motors and Control" by Gordon Fox, published by the McGraw-Hill Book Co.

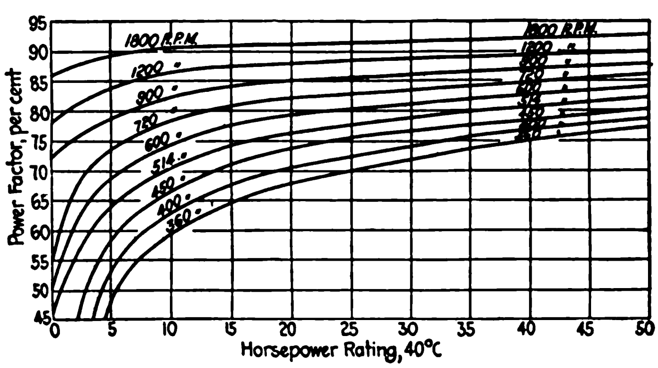


Fig. 6—Full-load power factor of 60-cycle, polyphase, squirrel cage, induction motors.

power factor in addition to causing poor regulation and increasing investment costs is the cause of a separate and distinct loss. This loss may be as high as 10 to 15 per cent of the cost of energy and is thus ordinarily well worth saving. A great deal may be done to hold up the power factor by keeping the induction motors loaded up to capacity, but the last step must invariably be made by other means.

Until comparatively recently the synchronous motor was considered very unsatisfactory, in fact almost impossible for general industrial use. This is because inherently it has no starting torque. It has been used from the very early days, but always where little or no torque was required in starting; that is, in conjunction with a clutch or some machine that could be unloaded, and often with an extra motor for starting it.

New developments are peculiar things. They seem to come when they will, forced on by undetermined causes. The recent development of high starting torque synchronous motors was not made possible by some new knowledge or discovery. All the factors in the design of such motors have been common knowledge for decades. The need has been as pressing. And yet for some reason it is only within the past few years that the super-synchronous motor, a synchronous motor that can be applied to any industrial drive, has made its appearance.

We have always wanted such motors because of their electrical characteristics, and their use has now been made possible because of the torque characteristics recently worked into their design. The economic utilization of the synchronous motor, however, is ordinarily justified only in the larger sizes and lower speeds. In the smaller sizes the cost per horsepower is high compared to induction motors. We can buy induction motors for $5 to $8 per horsepower, while for equivalent synchronous motors one must pay from $10 to $20 per horsepower. This is particularly true at the normal speeds, say 600 r.p.m. and above. On the other hand, at very low speeds the cost of induction motors per horsepower rapidly rises

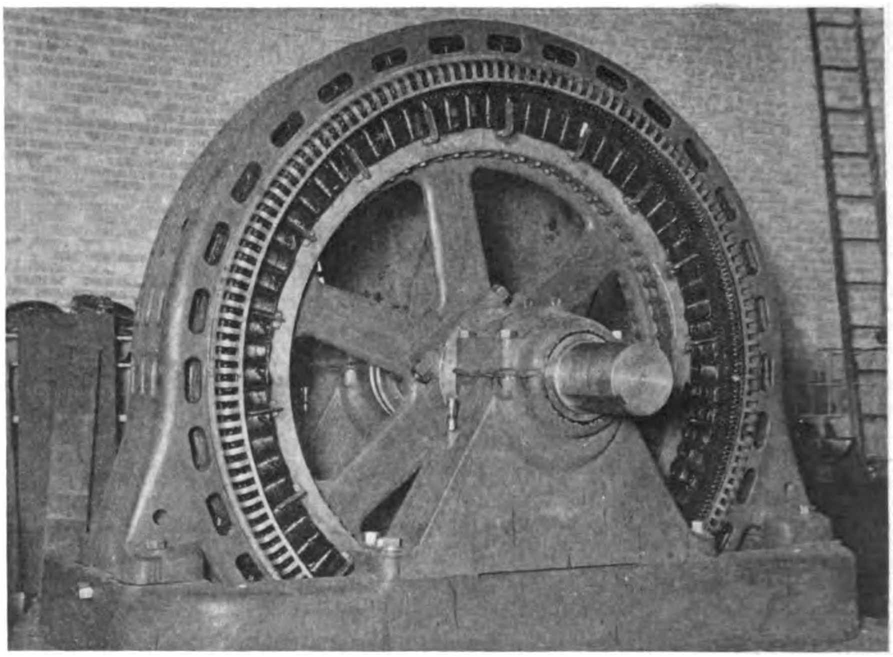


Fig. 8—High starting and pull-out torques characterize this synchronous motor.

It is rated at 600 hp., 80 per cent power factor, 100 r.p.m., 2,200 volts and develops a starting torque of 140 per cent of full-load torque, a 100 per cent pull-in torque, and a pull-out torque of 350 per cent of full-load torque. This Electric Machinery Co. motor is located in the plant of the Goodyear Tire and Rubber Co., Akron, Ohio.

Fig. 7—Operating characteristics of a typical, series motor.

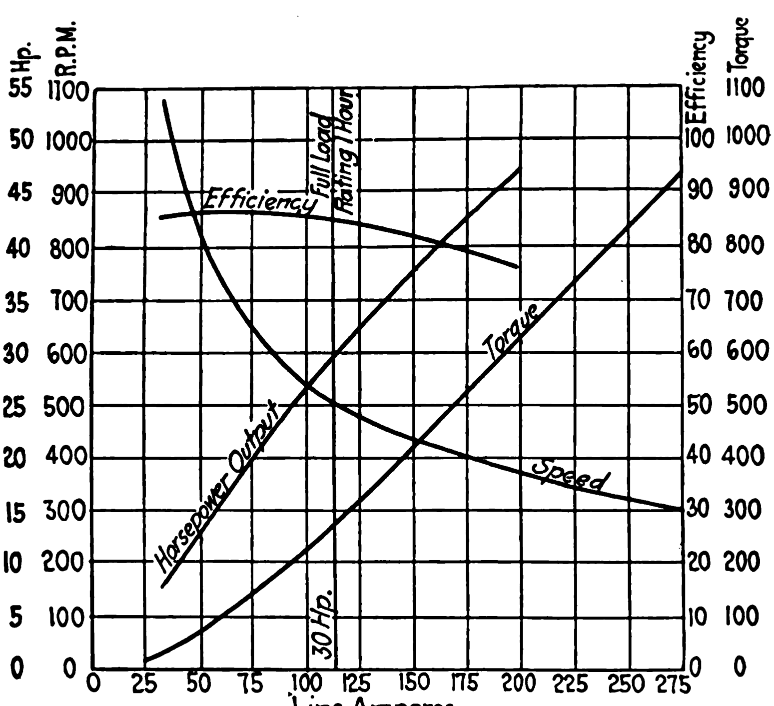
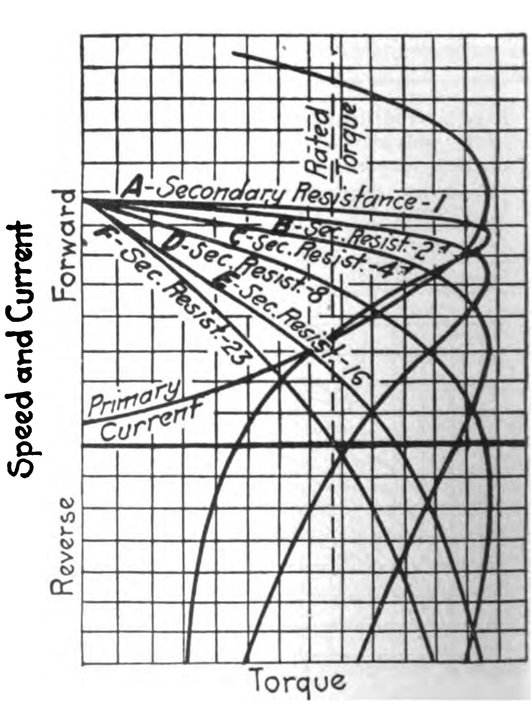


Fig. 9—Speed, torque, and current curves of a polyphase, wound-rotor motor with different values of secondary resistance.



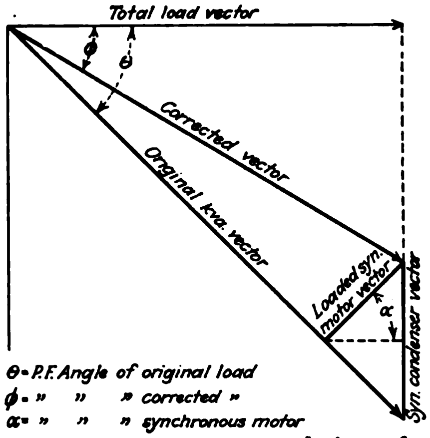


Fig. 10—General phase relations of load using induction motors operating at 70 per cent power factor.

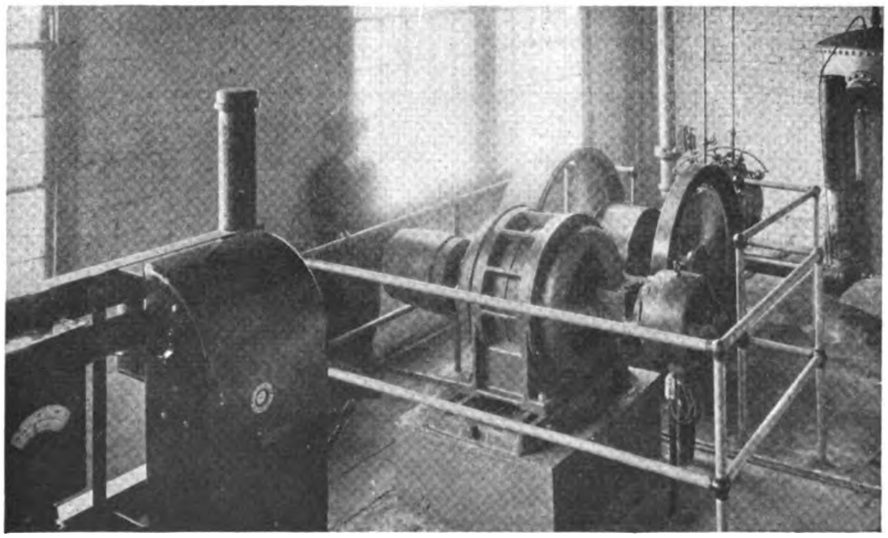
and their power factor abruptly declines. For this reason a low-speed synchronous motor may sometimes be used in place of a higher-speed induction motor and a reducing gear unit. It is not unusual to find that the combined cost of a high-speed induction motor and a reducing gear unit is as much as, or more than, that of a low-speed synchronous motor. When the difference in overall efficiency of the two possibilities is capitalized the chances are even greater for such to be the case. Here, then, is the big field for the synchronous motor, and assuming that it is under such circumstances that these motors are to be used, I shall point out some of the more important factors that make them so desirable from an electrical standpoint and so easy to use from a torque standpoint.

In the past it has been almost universal practice to use synchronous condensers for power factor correction. In recent years the use of static condensers has been urged. There are undoubtedly many places where both of these corrective means can be used to advantage, but in the average industrial plant there are two potent factors which drag down the balance arm in favor of the loaded synchronous motor.

Fig. 10 shows the general phase relations of the load of an ordinary induction motor plant operating at 70 per cent power factor. It is obvious that more corrective kva. is required if a condenser is used when the correcting vector rises vertically from the lower end of the initial load vector than when some of the existing load is driven by a synchronous motor and the resulting vector starts from farther up on the load vector. Just how much difference this makes is shown by Fig. 12 in which is plotted, for the same amounts of correction, the ratio of kva. of condenser capacity to kva. of loaded synchronous motor capacity when the latter is operated at its most effective power factor. The abscissas are original power factor. It will be noted that at the original power factor shown in Fig. 10, 43 per cent more capacity would be required were condensers used. Had the original power factor been 50 per cent the saving in capacity by the use of loaded synchronous motors would have been 100 per cent of the synchronous motor capacity.

Fig. 11—Here is a general-purpose synchronous motor used on an air compressor drive.

This General Electric motor is rated at 75 hp., 80 per cent power factor, 900 r.p.m., 220 volts and is installed at the Butler (Pa.) plant of the Fretz-Moon Tube Co. In addition to carrying the air compressor load it raises the plant power factor from 75 to 98 per cent. This motor is controlled through the medium of the manually-operated compensator shown at the left, a field switch, discharge resistance, field rheostat, field current ammeter and line ammeter.



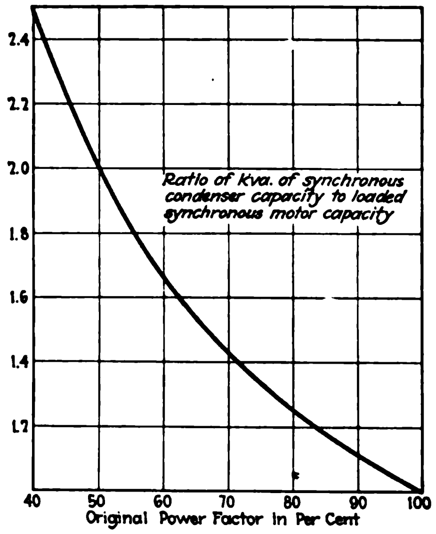


Fig. 12—This shows the ratio of synchronous condenser capacity to loaded synchronous motor capacity when the latter is operated at its most effective power factor.

This saving in capacity obviously means a saving in investment in corrective equipment. In any power factor correction problem, the subject of cost of correction is always of vital interest. Inherently a large part of this cost is fixed charges on corrective equipment. When synchronous motors are used in place of synchronous or static condensers, a saving is made in corrective capacity which is synonymous with investment cost, and thus the cost of correction is attacked on its main front. A still further reduction in investment charges is possible, because with loaded synchronous motors only that part of the motor cost which is above the amount which must be paid for some cheaper type of drive, say an induction motor, is chargeable to the correction account. It is thus evident that the use of loaded synchronous motors for corrective purposes, cutting down the investment cost in the two ways noted above, gives correction for a much lower figure than would otherwise be obtained. Often the correction is obtained at no cost at all.

As I have indicated before, the great fact that has retarded the use of synchronous motors is lack of torque at other than synchronous speed. Inherently it has zero starting torque and a low pull-in torque. The big development which has recently made the synchronous motor possible industrially is its change into a hybrid machine, half induction motor and half synchronous motor.

The induction part of the motor is used for starting, and the synchro-

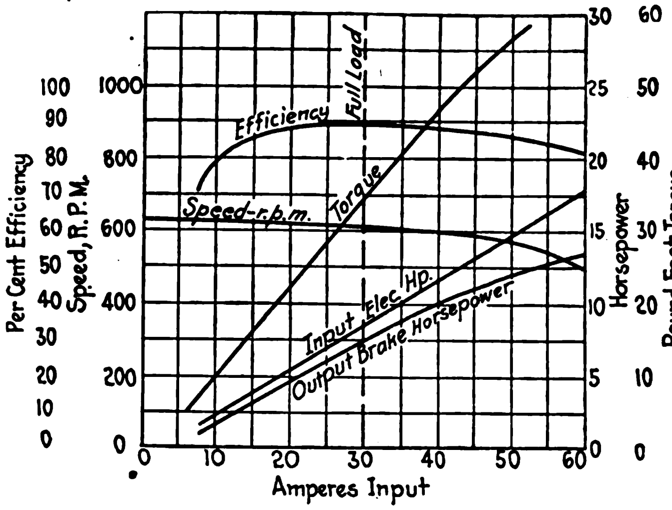


Fig. 13—Characteristic curves of a typical shunt motor.

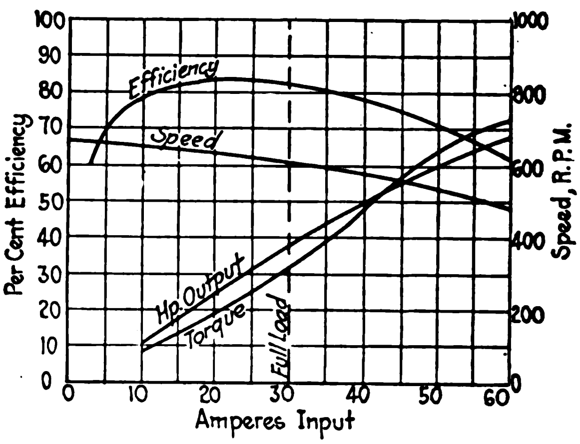


Fig. 15—Operating characteristics of a compound motor having 20 per cent series field.

nous part for running. By one method or another, a large number of relatively high-resistance bars are threaded through the faces of the poles and a very effective squirrel-cage rotor is thus formed. The resulting combined torque characteristics given to the motor are very satisfactory. Anything in reason may be obtained. The company with which the writer is associated has installed synchronous motors having starting torques of 140 per cent, pull-in torques of 100 per cent, and pull-out torques of 350 per cent of full-load torque. Such a motor is shown in Fig. 8.

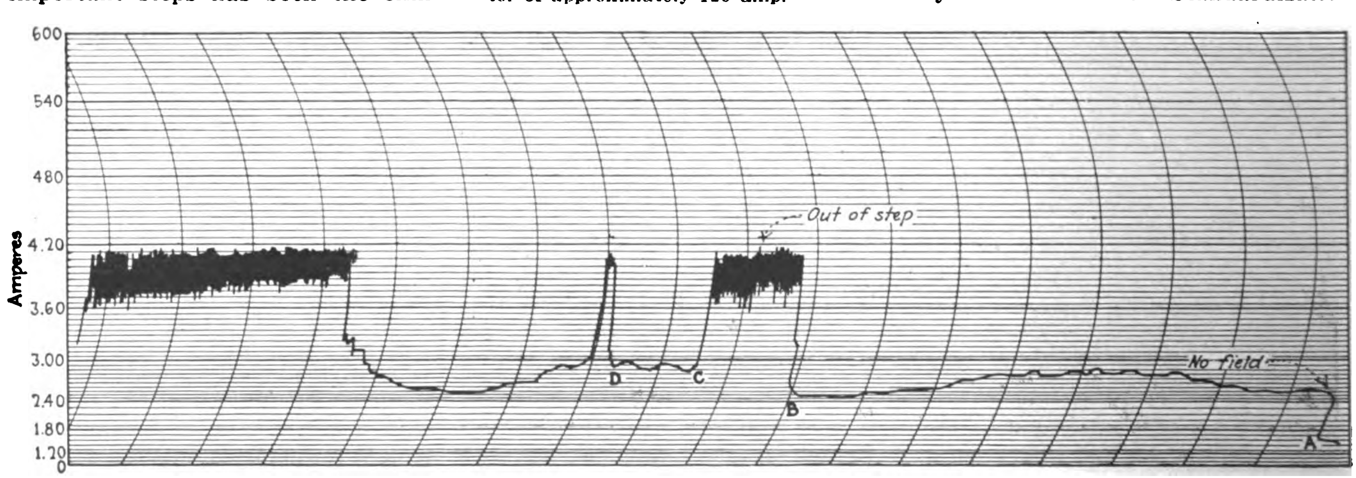
There has been, however, one other disadvantage of the synchronous motor compared to the induction motor, which I have not yet mentioned. It has always carried around with it a lot of excess baggage in the form of excitation equipment such as belt-driven exciters, exciter field rheostats, motor field rheostats, ammeters, and similar equipment. In the adaptation of the synchronous motor to industrial uses one of the important steps has been the elimination of this equipment. Most large plants have a direct-current distribution system. Where this is the case, advantage may be taken of it and the exciter and all rheostats and meters may be entirely discarded. The fields may be designed to operate on the system voltage with a liberal heat rating. Any voltage changes then only slightly modify the power factor. In our own plant we use no field equipment excepting one field contactor operated by a relay which in turn is actuated either by the secondary frequency, the primary current, or time. At the proper moment the field is automatically thrown on or dropped off and no adjustment or attention is needed.

This shift has, however, decreased the reliability of the excitation. Where the field current is taken from the plant system we must face the possibility of failure of the field without failure of the a.c. side. However, by the improvements of rotor design mentioned before, making high, squirrel-cage torques available immediately on failure of the field we have a motor which will carry its load even without a field.

The remaining step which has already been taken is to build heat capacity into the motor so that when the field fails and the motor starts to operate as an induction motor and thus take a larger stator current as well as a rotor current, there will be no overheating for a reasonable time—such a time as is ordinarily required to restore the d.c. service. As a measure of the heat capacity we have been specifying that the motor shall operate for 15 min. as an induction motor at full load without dangerous overheating. This would mean that the maximum temperatures should not exceed those given by the A.I.E.E. Standardization

Fig. 14—Operating a synchronous motor without a direct-current field.

At *A*, while the motor was under normal load, the field switch was pulled and the line current drawn by the motor increased from 150 amp. to approximately 260 amp. The significant fact is that the motor did not pull out of step. At *B* a peak load came on, incident to starting a new load cycle, and the motor pulled out of step and operated that way until the load dropped enough to allow it to pull back into step, as at *C*. This graphic chart was taken on a 600-hp., 2,200-volt, 100-r.p.m., synchronous motor having a full-load current at unity power factor of approximately 125 amp.



Rules for the various classes of insulation.

The ability of a well-designed synchronous motor to carry its load for short periods without excitation is well illustrated by the chart shown in Fig. 14. Here a graphic ammeter was connected in the circuit feeding a 2,200-volt, 600-hp., 100-r p.m., synchronous motor. The load follows a 6-min. cycle. The current during most of the cycle is between 130 and 150 amp. In Fig. 14 at *A* at the right-hand end of the chart, the current is just about this value.

At this point the field was opened and immediately the current approximately doubled. The significant fact is that the motor did not pull out of step. About the middle of the chart, however, a new cycle is begun and the peak load at the beginning at point *B* pulls the motor out of step. This is evidenced by the large increase in current and the oscillation of the instrument pen at slip frequency, between *B* and *C* in Fig. 13. Shortly the load drops somewhat, and the motor pulls back into step at *C*, only to be pulled out again for a brief interval a few moments later. The points where it pulls out of step and drops in again are distinctly evident. This shows very clearly how short interruptions to the excitation may be inconsequential so far as the operation of the motor goes.

There is one other possibility offered by the synchronous motor of which advantage has been taken. It can be stopped very quickly by dynamic braking; that is, by disconnecting the armature from the line and connecting it to a resistance, leaving the field connected to the direct-current power supply. The motor then acts as a generator and the retarding torque may be adjusted by changing the resistance into which it is discharging. On drives where it is necessary to have an emergency means of stopping, this becomes very desirable, for in itself the synchronous motor comprises not only a very satisfactory slow-speed motor, but also an equally satisfactory brake. When the field is supplied from the plant direct-current distribution system and the motor is to be used for dynamic braking, means must be taken to stop the motor automatically on failure of the direct-current, power supply.

This completes the picture I have roughly attempted to sketch. It comprehends the entire industrial world in which the vast majority of the motors, and by far the largest part of the load, consists of induction motors with their relatively low average power factor. To make this load economical from an electrical standpoint, something is required to raise the power factor. For this purpose therefore, it is suggested that a small number of large synchronous motors be scattered systematically around the plant. Each will carry load so as to operate at a power factor which will make its corrective effect most useful. The resultant whole will then be satisfactory both from the mechanical and the electrical standpoints.

Control of Window Light Deserves Attention

ALTHOUGH reflectors are employed almost universally today in the artificial lighting of factories, offices and other buildings, to direct the light where it is needed and to insure that the largest possible volume of light will be available, we have not given much attention to the control of natural light that pours in through the windows. The inconsistency of this was presented with most interesting evidence and many practical suggestions by Professor H. H. Higbie of the University of Michigan, speaking before the Twentieth Anniversary Convention of the Illuminating Engineering Society.

Discussing the effect of the various means of control upon the quantity and quality of the window illumination, Professor Higbie presented data from numerous surveys embracing shades covering top of window, shades covering bottom of window and Venetian blinds covering the whole of the window. "So far, all our findings appear to indicate," he said, "that control of light from windows by means of Venetian blinds is better than control by shades covering the lower sash, which itself is better than control by shades covering the upper sash."

"Whatever may be the merits of using roller shades of material having good transmitting properties, the fact remains that most window shades in ordinary use transmit very little, and such control as they exercise is by merely absorbing and destroying the light. In contrast with such a wasteful method, the Venetian blind presents a solution of the problem which seems to have great possibilities, in that the light may be redirected and made useful instead of being absorbed. If the slats be sloped up inward, the light from sun and sky is largely reflected back out of doors and all values of illumination in the room, maximum and average as well as minimum, should be decreased. If the slats be sloped down inward (or up outward) and are of light color so as to have good reflecting value, a considerable part of the light striking the window from outside, which otherwise would pile up near the window where not needed, is either thrown directly to the rear of the room where most needed or is thrown first to the ceiling and from it reflected more or less effectively back to working planes preponderantly at the rear of the room.

"The result obtained by changing the slope of the slats is easy to follow with the unaided eye, it being possible to throw a vaguely defined bright zone across the ceiling to the rear wall; and by means of a photometer it is easily shown that great increases may be produced in either the horizontal or vertical illumination at the rear of the room, with corresponding decreases in the maximum illumination near the windows."

In an analysis of natural illumination through Venetian blinds, Professor Higbie said: "From a theoretical viewpoint it appears that Venetian blinds, properly constructed and used, should have an advantage over all the ordinary types of window shades in that they are able to redistribute the light which they intercept and render it useful, instead of merely absorbing and destroying it. Control of natural illumination in interiors by means of roller shades which cover the upper part of the window is the least desirable method. It is better to use shades which cover the lower portion of the window, the roller being mounted at the meeting rail of the upper and lower sash, or at the window sill, or adjustable in height. It is best to use Venetian blinds, which operate to redistribute the light rather than to absorb it. In some cases such blinds may be adjusted so as to render the illumination not only better distributed but actually higher at critical points than it would be with bare windows. The amount of improvement of illumination depends upon a proper finish of the slats for high reflecting power, and upon a proper adjustment of their angle. In the cases tested, this angle lay between horizontal and thirty degrees below horizontal as we look along the slats into the room."

Getting the Most from Silent Chain Drives

used in industrial plants, by making sure that they are properly designed for the service conditions, carefully installed, and given the necessary attention

By A. B. WRAY
Chief Engineer, Morse Chain Co., Ithaca, N. Y.

THE silent chain drive is becoming a factor of ever increasing importance in the transmission of power. Inasmuch as they are made in sizes ranging all the way from the drive employed in the head of a sewing machine to those that transmit 1,000 or more horsepower in rolling mills and similar installations, their field of application is very large. The development of the electric motor gave great impetus to the use of silent chain drives, as electric motors can be built in almost any size desired and installed close to the driven shaft, the only factor limiting this distance being the form of transmission used. It was not always feasible or satisfactory to use a belt drive. On the other hand, a gear drive is noisy and often precluded placing the motor at the most advantageous place. Under these conditions, the silent chain drive has offered a number of worth-while advantages which have been appreciated by industrial plant operators.

The policy of the silent chain drive manufacturers has had a good deal to do with the success of this type of drive. They have preferred to design the drives themselves after having full specifications covering the requirements. They have considered each application as an engineering proposition and recommended what they considered most suitable for the conditions, thus avoiding troubles that would occur if the design had been selected by one who is not a specialist or familiar with designing this type of drive. There have, of course, been failures, but the manufacturers have either furnished replacements to make the drive successful, or took it back on a basis that kept the confidence of the users.

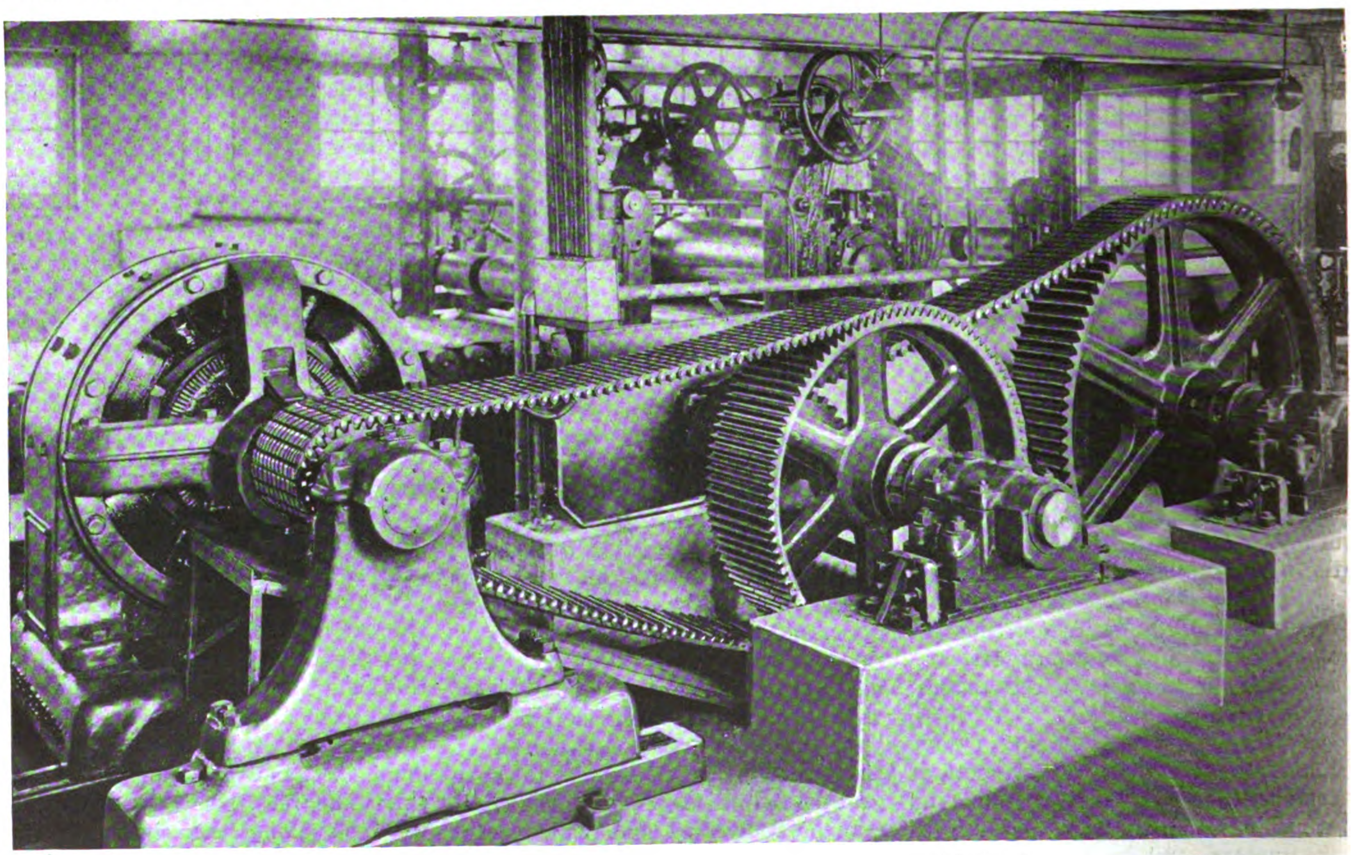
This shows a double-reduction chain drive to a set of rolls in a lead mill.

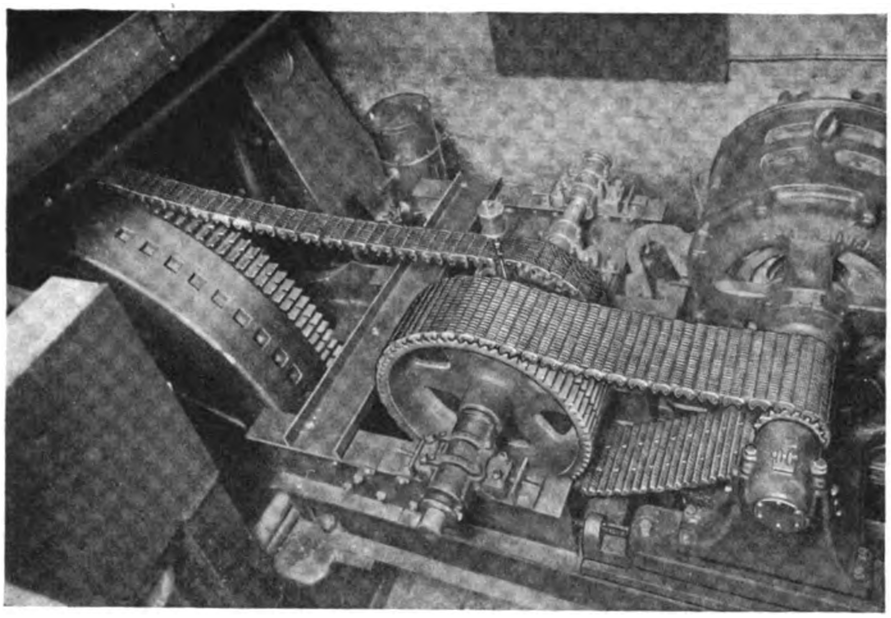
The first reduction is from 250 to 63 r.p.m.; the second reduction is from 63 to 19.7 r.p.m. Both chains operate on 120-in. centers. The motor is rated at 125 hp.

There are engineers who believe that their service requirements are unusual; that the product going through the machines is too delicate for a positive drive. For a number of years textile mills, particularly, were fearful that the positive drive could not be used on certain of their machines. Fifteen years of successful service on spinning frames, twister frames, spoolers and preparation machines has demonstrated that few, if any, of these machines cannot be driven to advantage by silent chain drives.

Some operators have been afraid of their machines jamming, thus breaking the machine and spoiling the work, but seldom have their fears been justified. The chain drive manufacturers are in position to furnish shearing pins or slip sprockets where something of this kind is really necessary.

There are today very few machine tools that are not furnished with





Here an ammonia compressor is driven through a double-reduction chain drive.

The first reduction is from 850 to 198 r.p.m. The chain is 10 in. wide and operates on a center distance of 36 in. For the second reduction of 198 to 45 r.p.m. a 5-in. chain is used, which operates on 84-in. centers. The motor is rated at 75 hp.

individual motor connected through a silent chain drive, and while driving the motor is the principal use on machine tools, a chain is often used to replace a train of gears, or other drives for the feed auxiliaries and special mechanisms. Engineers with special problems to solve have come to the silent chain manufacturers and so there have been developed special uses and special chains for a large variety of purposes.

Thus, the manufacturers of hoisting machinery, power shovels, ditching machinery, dredges, and the like have found the silent chain drive ideal as a connection between the electric motors or gas engines that drive the machine. Gearing would be noisy and preclude placing the motor or engine at the most advantageous point. Belting is out of the question for such applications.

Silent chain drives have been used for a good many years in steel and brass rolling mills on hot rolls, cold rolls, wire drawing benches, and so on. The quality of the work produced has been superior to that produced on similar machines with other types of drives.

In large power drives such as are used in rolling mills and power stations, the chains often transmit over 1,000 hp. In such installations, a silent chain has the advantage that it gives a positive drive and requires only a short center distance between the two shafts. The largest chain drive ever constructed transmits 5,000 hp.

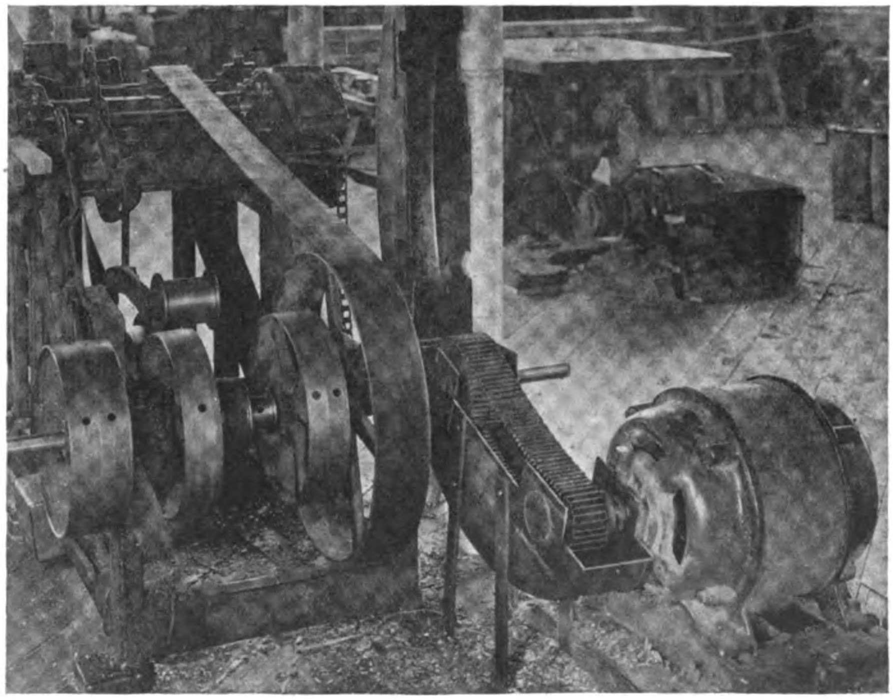
Manufacturers of refractory bricks have for a good many years found that the silent chain drive meets their requirements better than any other form of drive. The service is unusually severe and the drive does not give the life that it does under more favorable conditions, but on direct comparison of results obtained with other types of drive they find the chain drive to be the most economical.

Printing establishments are large users of silent chain drives. Most of the large city newspapers use silent chains for driving the multiple presses. At first the chain manufacturers felt that the drive was ideal for the rotary presses, but were a little afraid of the flatbed and color presses on account of the reciprocating motion of the bed. In the past few years a great many of these presses have been successfully driven. When proper attention has been given to the dashpots on the presses, chain drive has not caused any trouble.

The manufacturers of silent chain drives do not claim that their drive should be used on every possible application. Their success has largely come from considering each drive as an engineering proposition and recommending a chain drive only where they felt that it was better than any other form of drive. Drives on extremely long centers are not suited for silent chain; nor are drives on excessively short centers. Very often a silent chain drive can be used on the same centers as a gear drive, but this is accomplished by the use of smaller sprockets. Machines that operate with a reciprocating motion, or that impose vibratory or shock loads, should be looked to with care. Of course, if there is a sufficiently large balance wheel the load becomes fairly uniform, or a spring sprocket can be used to re-

In this case a 6-in. moulder is driven by a 10-hp. motor through a silent chain.

The reduction is from 1,500 to 800 r.p.m. Distance between centers is 18 in.



lieve the chain from the shock. This will improve the operation, but does not correct the trouble as does the balance wheel.

There have been cases of misapplication and abuse of the chain drive and the chain manufacturers have tried hard to educate their users so as to avoid these dangers and troubles.

It must be borne in mind, however, that the proper selection, installation and maintenance of a silent chain have much to do with the reliability and quality of service that a chain drive will give. This is equally true of every piece of equipment.

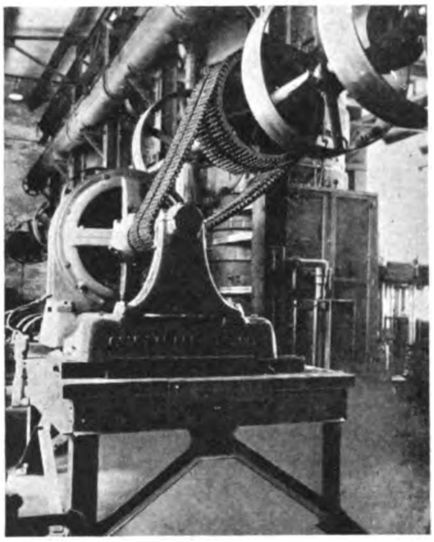
The principal factors influencing the design of a silent chain drive are the power to be transmitted, the speeds of the driving and driven shafts, the center distance, and the service. The higher the rotative speed, the smaller the pitch it is necessary to use. All manufacturers of silent chain drives use circular pitch. For mechanical reasons, it is not good practice to make a chain more than approximately 12 times the pitch in width. This limits the amount of power that can be transmitted by a certain pitch, although it is possible to use multiple-strand drives, as many as four strands having been used successfully on a single drive.

It may be interesting to discuss for a moment some of the points that must be considered in laying out a chain drive.

Briefly, designing a silent chain drive consists in selecting the proper pitch, width of chain and number of teeth in the sprockets, and determining the shortest center distance for best operation, unless the center distance is fixed by other conditions.

The first step is to determine the proper pitch. In almost every case it is desirable to use the largest pitch possible and yet not exceed the maximum allowable rotative speed for that pitch. In some cases it is permissible to use a certain pitch at higher rotative speeds than would ordinarily be allowable for that pitch. When only small amounts of power are to be transmitted, it is sometimes necessary to use a smaller pitch than the rotative speeds would indicate, on account of the extremely narrow chain that would be called for in the larger pitch.

The second step is to select the proper number of teeth for the driver and driven sprockets. We have compiled a data table that



Lineshafts are frequently driven through silent chains.

This chain transmits 200 hp. and gives a reduction of 575 to 154. It operates on 48-in. centers.

shows the minimum number of teeth for the driver sprocket and the maximum desirable for the driven one, with the desirable number of teeth for both. With this information we proceed to determine the number of teeth in the sprockets, working this out in the form of a proportion as follows:

Driver r.p.m. ÷ driven r.p.m. = driven teeth ÷ driver teeth

Having selected the number of teeth in the sprockets, we proceed to figure the chain speed in feet per minute, using the following formula:

(Driver teeth × r.p.m. × pitch) ÷ 12 = feet per minute

Having found the chain speed and knowing the horsepower to be transmitted, the total pull of the tight or driving strand of the chain is determined by using the following formula:

(Hp. × 33,000) ÷ feet per minute = total pull

Knowing the total pull, the next step is to select the width of chain. The table shows the allowable pull per inch in width for the different pitches. This, divided into the total pull, gives the width of the chain. It is always advisable to use the next wider chain than called for by the following formula:

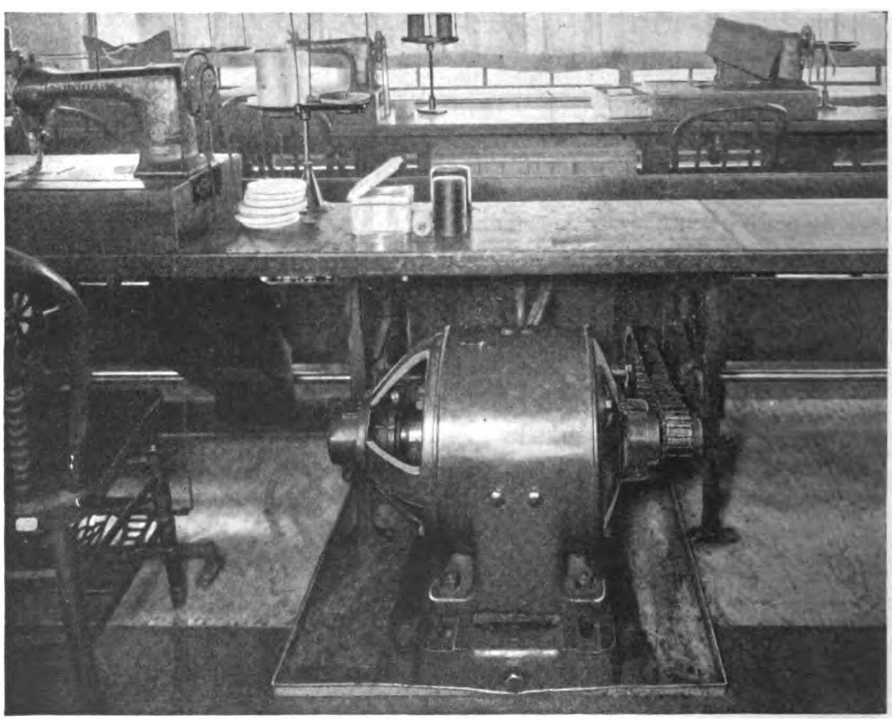
Total pull ÷ allowable pull per inch = width in inches

In a good many cases where service is continuous or severe. an extra-wide chain should be selected.

In motor drives the driver sprocket is almost always made of steel and hardened. It is only where there are a relatively large number of teeth in the driver sprocket and where the rotative speed is slow that it is safe to use sprockets made from semi-nickel steel castings or cast iron. Large cast-iron sprockets may be made up solid, split, spring or shearing pin type, according to the requirements and service.

Silent chain drives may be used to transmit small as well as large amounts of power.

The sewing machines are operated from a lineshaft which is driven by a 2-hp. motor through a silent chain 1¼ in. wide. The distance between centers is 18 in. and the chain gives a reduction of 1,100 to 417 r.p.m.



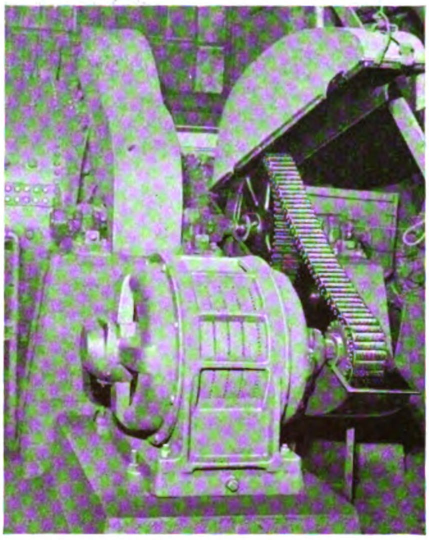
The designer of a silent chain drive has some choice as to pitch. If he wants a very quiet running drive, he will use a smaller pitch than designated. On a variable-speed drive he will sometimes select a pitch that will be over-speeded at the high speed, knowing that the drive will not run much of the time at that speed. If other conditions are favorable, he will sometimes select a shorter center distance than would ordinarily be suggested.

As mentioned previously, there are certain machines that are not suited for silent chain drives. These are machines that operate with a reciprocating motion, with only a very small or no balance wheel. Sometimes machines of that type can be driven by means of a spring sprocket. A spring sprocket has a rim mounted on the hub that is kept in balance by compression springs. These springs relieve the strain on the chain as the load changes.

Some machines are likely to stall and the users feel that a belt will slip and throw off in case of stalling, but the silent chain manufacturer is in position to furnish a shearing pin sprocket in which the number of pins can be varied so as to shear at any desired load. These pins can easily be renewed, in case they shear.

To get the best results from a silent chain drive, the installation should be made rigid. This calls for a good foundation; foundations and bearings should be rigid to prevent vibration or springing of the shafts. The sprockets must be carefully aligned and should be mounted near enough to a bearing to prevent any tendency of the shafts to spring, and should be securely fastened on the shaft to prevent shifting or misalignment. The shafts must be level and parallel with each other. When split sprockets are used, great care should be taken not to bruise the fracture where the halves go together. The bolts should be tightened equally, so as to bring no undue strain on the sprocket, which might cause failure.

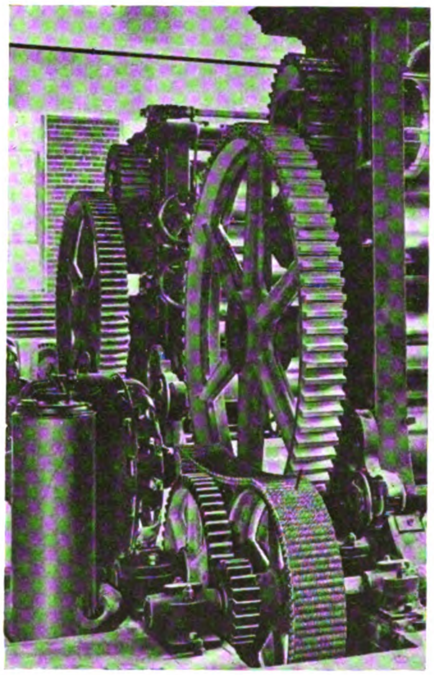
Care should be used not to drive keys in too hard. When installing spring sprockets or shearing pin sprockets, be sure to see that these are properly lubricated between the rim and inner member. When installing the shearing pin sprockets, it is suggested that only two shearing bolts be used at first. If these shear too easily, additional bolts can be added. Remember, too, that a silent chain should never be run tight. This prevents the proper action of the joint and proper engagement of the chain with the sprocket teeth. In consequence, it causes unnecessary pressure on the bearings and reduces the efficiency of the drive.



This silent chain is rated at 60 hp. and drives a ball mill.

Be sure that the joint pins are properly inserted in the chain, as shown in the literature of the chain manufacturer, and the washers securely riveted.

After the installation of a chain drive is complete, it should be carefully examined to make sure that it is operating properly, before it is put into service. Failure to do this may cause trouble.



This is one of three 50-hp. silent chain drives on the calenders in a rubber factory.

Operating on 54-in. centers, this chain gives a reduction of 690 to 138 r.p.m. It is 6 in. wide.

No piece of equipment will continue to operate at its highest efficiency without a certain amount of attention, and chain drives are no exception to this rule. Therefore, be sure that the drive is kept rigid, the sprockets in line and the shafts parallel. Misalignment of the shafts often occurs, due to shrinkage of timbers or settling of the building. The chain should be kept well lubricated, using oil when possible to do so. Greasing is often sufficient on large drives. If the chain becomes gummed up, it should be cleaned with kerosene and then thoroughly oiled before it is put back in service.

Sometimes there is a tendency for links in the chain to crowd together, or for the pins to protrude. This is the result of insufficient lubrication on starting and the cutting of the links as the chain flexes. This condition can usually be corrected and overcome by taking a screwdriver or chisel and spreading the links apart, and then thoroughly lubricating with a heavy oil. The oil used should be heavy enough to prevent the crowding together of the links.

A drive should usually be encased for safety and to prevent dust and grit getting into the chain. It is not necessary to run the chain in an oil bath, although this is often done, as under most conditions it can get along with considerably less lubrication.

On drives where the load is pulsating, slack should be kept to a minimum. On the other hand, no chain drive should ever be run with initial tension. In a vertical drive the slack in the chain should be watched to see that it does not become excessive; otherwise serious trouble may develop.

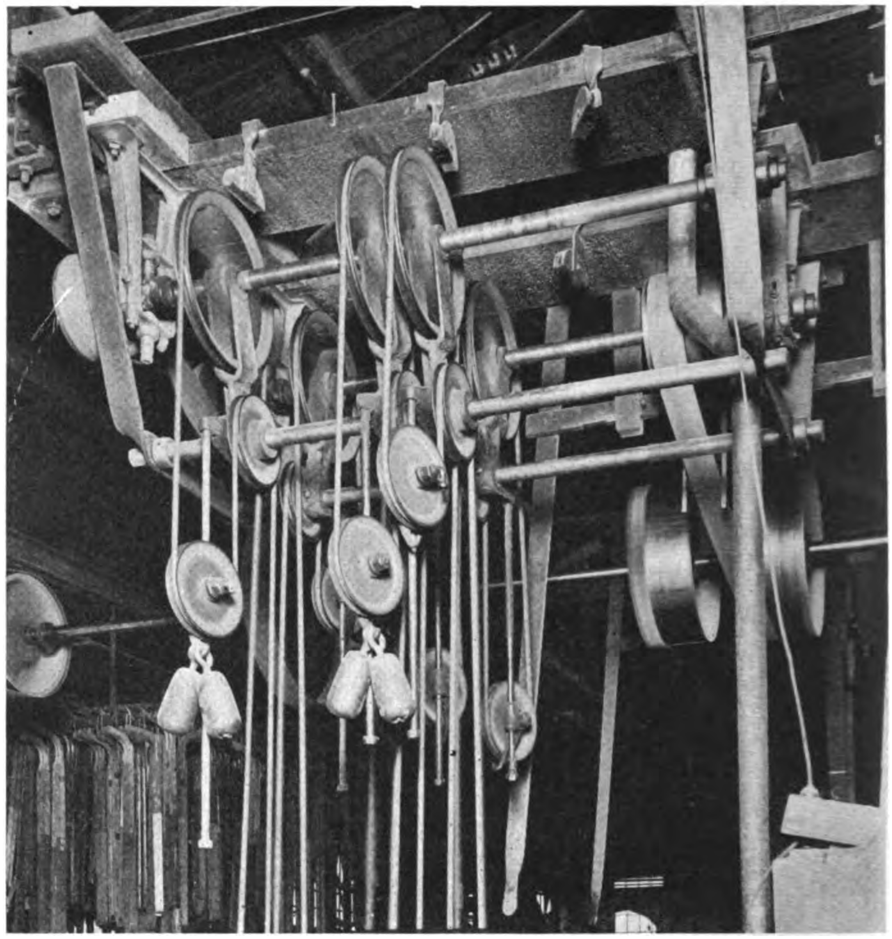
Although a good silent chain has years of service built into it, and will deliver this service if it is given the proper chance to do so, it will not run forever. However, it gives plenty of warning that wear is taking its toll, the lengthening in pitch being visible by noting how far out on the teeth of the sprocket the chain climbs. The silent chain adjusts itself to its true pitch circle on the sprockets and eventually reaches a point where it will jump over and skip the teeth. It should be replaced before this point is reached, as otherwise it will destroy the sprockets.

Methods of

Reducing Friction Losses

in power drive equipment by using better bearings and rearranging drives to improve operation

By G. A. VAN BRUNT
Managing Editor, Industrial Engineer



This rope imposes severe operating conditions on the shaft bearings.

Fafnir ball bearings are used in this high-speed drive to a woodworking machine for making plow handles, in the plant of the B. F. Avery Co., Louisville, Ky.

IN THE process of transmitting mechanical energy from the motor through belts, gears, or chains to the spindle of the driven machine there is a loss of power. This loss may be comparatively large or small, depending on the type of mechanical power drive equipment used, its condition, and several other factors. In any case, this loss is due to the friction of moving parts. Friction is a troublesome, but inevitable, consequence of the rotation cf a shaft in its bearings. Although friction serves many useful purposes, as for example when power is transmitted through a belt drive, it is the cause of a great waste of power.

No one knows how much power is unnecessarily wasted through friction and otherwise in the industrial plants in this country. Expressed in terms of horsepower, or in dollars and cents, this total loss in power would undoubtedly be larger than most of us realize. As was stated above, a certain loss of power is inevitable in the operation of power drive equipment, but in the great majority of industrial plants there are many places in which power losses that are primarily due to friction can be considerably reduced. It is the purpose of this article to consider some of the ways in which this can be done. Under the competitive conditions that exist today, and with power at its present cost level, serious efforts to reduce power wastes to a minimum can easily be justified.

Frequently, operating executives do not know how much power is being wasted, through friction, in their plants. It is not a difficult matter to check up on this, and the results are almost certain to be interesting and instructive—probably surprising. All that it is necessary to do is to measure the power input to the motor driving a lineshaft, say, with all of the machines running idle. This will give the power loss in the motor, belts, line- and countershaft bearings and so on. If it is desired to determine the loss in the various elements of the system this may be done with equal facility. Thus, for the sake of accuracy the running losses of the motor may be determined by throwing the belt off and measuring the power input to the motor while it is running light. In the same way the power required to drive a lineshaft alone, may be found by throwing off all belts to countershafts, jackshafts and machines. With the data obtained in this way, one is in position to undertake constructive work looking toward the reduction or elimination of some of the power losses. Furthermore, such data make it possible to determine the effectiveness of any change which may be made for this purpose.

Individual motor drive is frequently advocated as a means of eliminating the power losses incidental to the operation of group drives. Under many conditions individual drives unquestionably offer a number of worth-while advantages and are worthy of consideration, particularly in the case of new installations or where extensive alterations to, or revamping of, an existing installation is necessary. However, in many cases, it is not desirable, or feasible, to adopt individual drives for all production equipment, and the operating executive must allow the power drive equipment to remain in substantially its present form. His only recourse is then to reduce friction losses to the lowest point by putting the power drive equipment in the best possible condition.

Beginning with the lineshaft, misalignment of this is a very common and important source of power losses. Granting that the lineshaft was properly erected and aligned at first, settling of the floors and foundation and warping of beams in mill-type

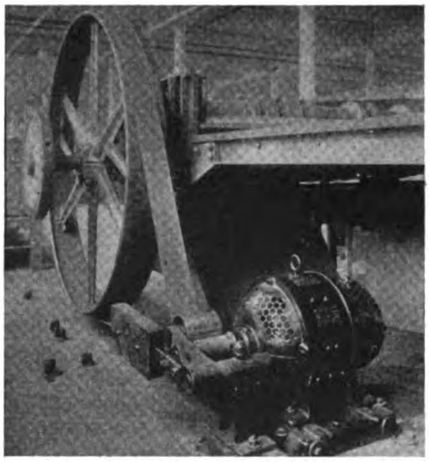
buildings almost always takes place, with the result that the lineshaft is thrown out of alignment. This will increase considerably the friction in the bearings and may cause whipping or bending of the shaft.

It is, consequently highly advisable to check lineshafts for alignment at intervals of a year or so. There are several methods of doing this, one of which was described in the article entitled "Erecting and Aligning a Lineshaft Drive," on page 398 of the September, 1926, issue of INDUSTRIAL ENGINEER. Briefly, the procedure is as follows:

The shaft is leveled with a level having a V-base, by adjusting the vertical screws in the hangers. A strong cord line is then stretched parallel to the shaft and fastened to targets, which may consist of boards nailed to the joists. One target should be nailed firmly, while the other may be fastened by a single nail and then adjusted so that the distance from the line to the shaft is the same at each end before it is fastened securely. The next step is to see that the distance from the line to the shaft is the same at all hangers. After the vertical and side adjusting screws in the hangers have been adjusted and tightened, the shaft should be carefully checked again with the level and with the line.

Nor are the harmful effects of misalignment confined to lineshafts. Gear and chain drives often get out of line, which increases friction losses and wear on the parts.

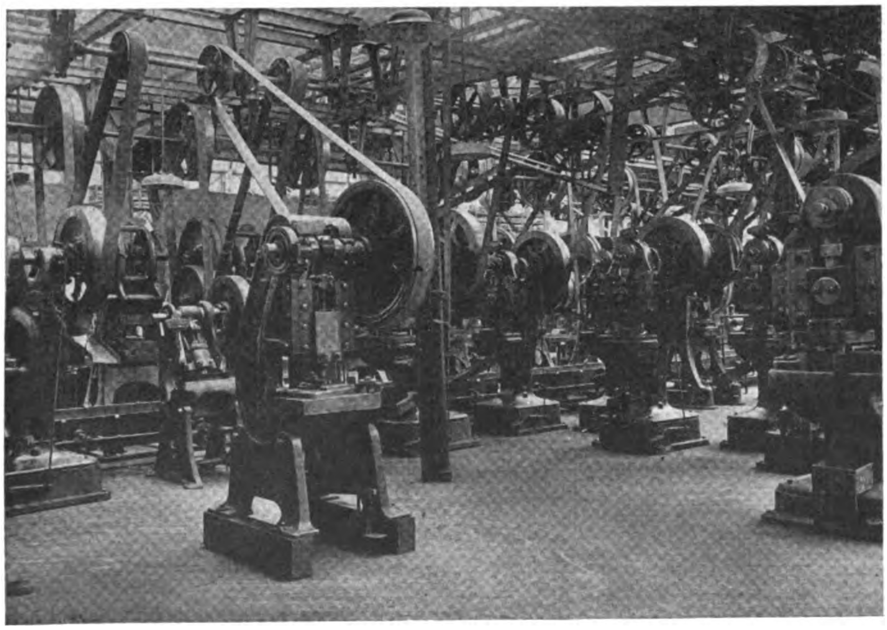
Ball and roller bearings are widely used on lineshafts and are a very effective means of reducing the friction. There are on the market a number of makes of both ball and roller bearings that can be used to replace plain, babbitted bearings, without much trouble or expense for installation. One of the incidental, but important advantages that accrue from the use of ball or roller bearings is the decided reduction in maintenance expense. These bearings require greasing a few times a year at the most, instead of daily, or at very frequent intervals, as is the case with plain bearings.



Here is a short-center belt drive in which the pulley ratio is 1:30.

The motor pulley is only 2 in. in diameter, whereas the driven pulley is 60 in. A Pulmax drive (Bird Machine Co.) is used on this installation, which is located in a paper box factory.

The use of ball and roller bearings on lineshafts was discussed, and some of the types available illustrated in an article on page 229 of the May, 1924, issue.



In this instance roller bearings are used on all of the lineshafts.

This is the light punch press department in a large automobile plant. Hyatt roller bearings are used in the lineshaft hangers.

Much can oftentimes be accomplished in the way of reducing friction losses by eliminating as many jack- and countershafts as possible and driving the production machines through clutches or clutch pulleys. A good deal of power may be wasted in countershafts, unless these are equipped with anti-friction bearings, while loose pulleys are frequently a prolific source of trouble. Furthermore, constant shifting is hard on belts. Belts subjected to much shifting usually run out of true, sufficiently so that one edge and sometimes both come into contact with the shifting lever, with the result that the belt is eventually badly frayed. This condition is oftentimes responsible for the destruction of a belt long before it has given the service which it really is capable of giving. Many production machines are now equipped with cluch pulleys as an integral part.

Again, much power may be wasted by running groups of machines, or lineshafts, that are not actually in use, for example, when only a portion of a department is working, as on night shifts or at certain seasons of the year.

Under these conditions friction cutoff couplings and clutches can be used to enable a section of shafting or a machine to be disconnected or connected at will by moving a lever. A friction cutoff coupling is ordinarily used to connect and cut off two sections of shafting. One-half of the coupling is usually keyed solidly to one shaft while the other half is keyed either solidly or by a feather key to the other shaft. By different mechanical means such as a lever, toggles, springs, spiral gears and other devices, one-half of the coupling is made to seize and clamp the other half. The friction clamping devices of clutches and cutoff couplings are quite similar in several types, particularly when one concern manufactures both cutoff couplings and clutches. In several such types half of the clutch is keyed on the shaft and the other half fastened to a loose pulley or gear which may ride on the shaft or ride on a special sleeve or extended hub. Clamping action is usually secured by a lever. In reality, cutoff couplings and clutches differ but little in principles of construction other than is made necessary by the different uses.

Inasmuch as mistakes are sometimes made in selecting a clutch of the proper capacity, it may be well to say that perhaps the best general rule to apply in the selection of a clutch is to use one with the full rated capacity of the pulley to which it is connected at the rated speed, or of a double belt of the proper width for the pulley. Another reason for installing a clutch of the full rated capacity of the pulley which it may be called upon to drive, is that manufacturers frequently under-specify the power required to drive their machines; also, when the clutch is mounted on the lineshaft, in particular, additional or larger machines may be added at any time. For this reason, for a lineshaft cutoff coupling it is always well to install a coupling of the full capacity of the lineshaft. It is also advisable when figuring the horsepower rating of a friction clutch or coupling, to take into consideration the effect of suddenly applied loads and the running speed, rather than simply the power transmitted through the clutch when engaged. Obviously, there is much more slippage when engaging a clutch on a fast-running shaft than on a slow-speed shaft. This, of course, affects the life of the friction surfaces.

Other important points to be considered in the selection and operation of clutches and cutoff couplings are discussed in articles in the January and March, 1924, issues of INDUSTRIAL ENGINEER.

Unless properly laid out, short-center belt drives are frequently troublesome from several standpoints, among which are the difficulty of obtaining sufficient arc of contact on the pulleys, and the consequent necessity of using high belt tension to prevent slipping. High belt tension, in turn, greatly increases friction, thus wasting power, causes bearings to run hot, and may cause them to burn out. In addition, excessive tension is injurious to a belt and will tend to shorten its life.

As a remedy for these conditions, wide use is made of idlers or belt tighteners. Oftentimes these idlers are home made from parts that are available at the moment, and do not give the same quality of service that can be obtained from a properly designed idler, of which there are several different makes on the market.

There are two general types of idlers employed to tighten belts. One general type consists of a pulley which may be moved up and down, horizontally, or on a slant by a screw, or rack and pinion. Means are usually provided for locking the idler pulley in position, so that it will maintain a certain tension. With this type there is no means of determining the tension applied to the belt, with the consequent danger that excessive tension will be used. Furthermore, any regulation of tension to meet changing conditions must be made manually. In another common type of idler, use is made of an idler pulley on a swinging arm, tension being maintained by means of counterweights or by springs.

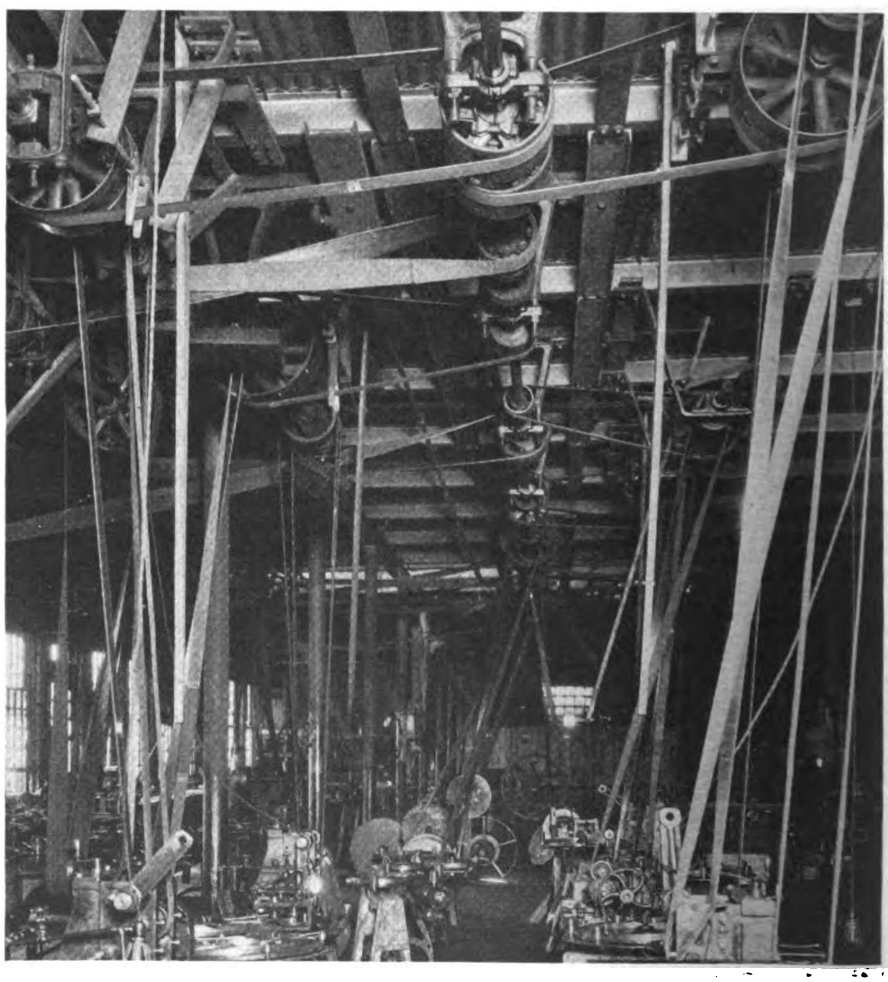
In the use of home-made idlers, particularly, the mistake is often made of placing the idler so that it serves merely to increase belt tension, without materially increasing the arc of contact on the pulley. On the other hand, increasing the arc of contact, which means putting more of the belt in contact with the pulleys, tends to eliminate belt slippage so that a lower belt tension can be used. This in turn reduces wear and tear on the belt and saves power by lessening the friction in the bearings.

Other points which should be kept in mind when using an idler or belt tightener on a short-center drive are: (1) Care must be taken to see that the belt is not put under too high tension. (2) The idler pulley must not be too small for the thickness of the belt used. (3) It is advisable to use a cemented, endless belt. In any case, the belt joint must present a smooth surface on both sides of the belt.

Short-center belt drives possess several advantages and when properly laid out can be made to operate very satisfactorily.

When making a survey of a plant for the purpose of reducing the losses in power drive equipment one should not lose sight of the fact that the care which belts receive has a good deal to do with their efficiency. A belt which is harsh or dry and glazed will have more tendency to slip then will a belt which is soft and pliable and presents a good frictional surface to the pulleys. When it is found that a belt is slipping there is a natural tendency to conclude that the

Ball bearings reduce the power required to turn these lineshafts.
This shows one of the departments in the plant of E. C. Atkins & Co. at Indianapolis, Ind., in which the lineshafts are equipped with SKF ball bearings.

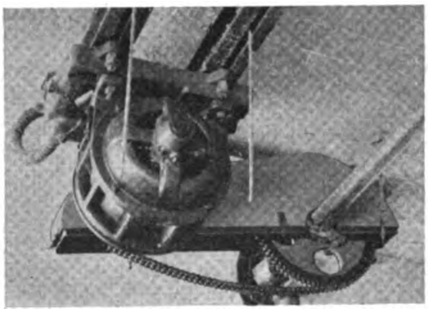


belt tension is too low. Tightening the belt may help to prevent slipping, but it also increases the pressure and consequently the friction in the bearings. Likewise, there is a decided danger of stretching the belt beyond its elastic limit, thus decreasing both its life and efficiency.

As another possible remedy the use of excessive amounts of belt dressing is resorted to. If the dressing is a home-made concoction, as is often the case, there is a fair chance that it will be injurious in one way or another. The care of belts is discussed in the article on page 464 of this issue. Consequently it need not be considered here, except to say that if a belt is of good quality, is of the proper width and thickness for the drive, and is kept clean and in good condition, it can be depended upon to render the service expected of it without putting it under a tension greater than is sanctioned by good practice.

Chain drives may also be employed to advantage when the distances between centers of the driving and driven shafts is short. One of the advantages of a chain drive, which in some installations is of considerable importance, is that there is no slippage, as in the case of belts. With a chain drive every revolution of the driver means a definite number of revolutions of the driven shaft or wheel, according to the speed reduction ratio, and this ratio is maintained continuously, until the drive is worn out.

In general, there are three types of chains employed in power transmission work: block, roller and what are known as silent chains. Block and roller chains are most often used for connecting up two or more



Power is transmitted from this 10-hp. motor to the lineshaft through a chain drive.

A double, Diamond High Speed chain operating on 30-in. centers, and giving a reduction of 4:1 is used on this installation in a Southern cotton mill. The lineshaft drives nine duck looms. In this illustration the lower part of the case has been removed to show the chain.

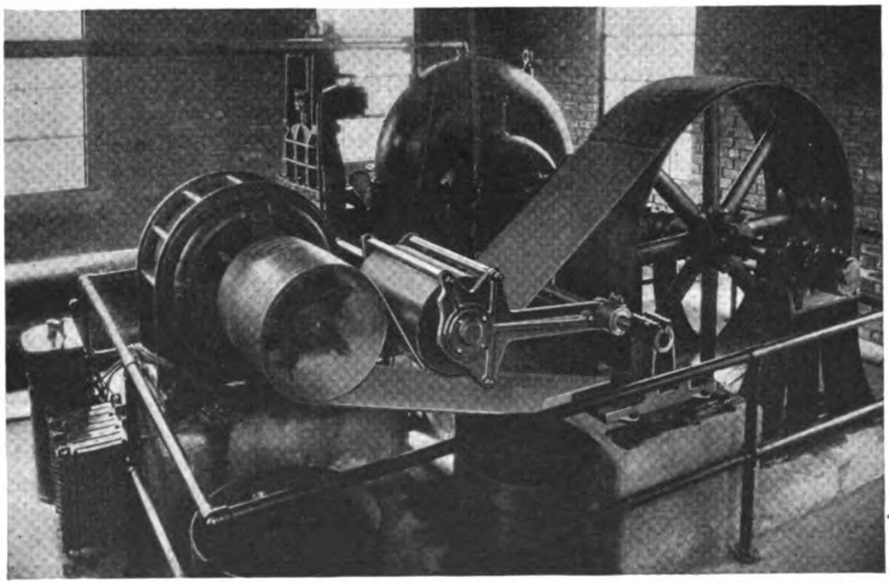
shafts of a machine to give a positive ratio between them. Block chains are seldom used for power transmission of over a few horsepower, but are frequently employed on small machines. Well-designed roller chains are used commonly up to about 25 to 30 hp., and in some cases much higher.

Block chains consist of a solid link joined by a pin and side plates. The pitch of a block chain is the distance from the center of one tooth opening to the center of the next or, as it is most often measured, from the center of one pin to the corresponding pin in the next link.

Roller chains consist of links or plates fastened together by pins fitted through rollers, although some cheap grades are fastened by pins only and are not adapted to high speed or heavy service. In most roller chains the links are of equal length; consequently, the pitch, the distance from pin to pin, is approximately one-half of that of block chains of corresponding size of links which have twice the pitch. For this reason, a sprocket for a roller chain has twice as many teeth as a sprocket for a block chain of twice the pitch.

In this installation the belt speed at times exceeds 6,000 f.p.m., 200 hp. being transmitted at this speed.

The turbo-volute pump shown here is in service in the Hillview Levee and Drainage District, Hillview, Ill. A two-arm, opposed Lenix drive is used to maintain the proper tension on the belt and increase the arc of contact on the motor pulley. The driving belt is 22 in. wide.



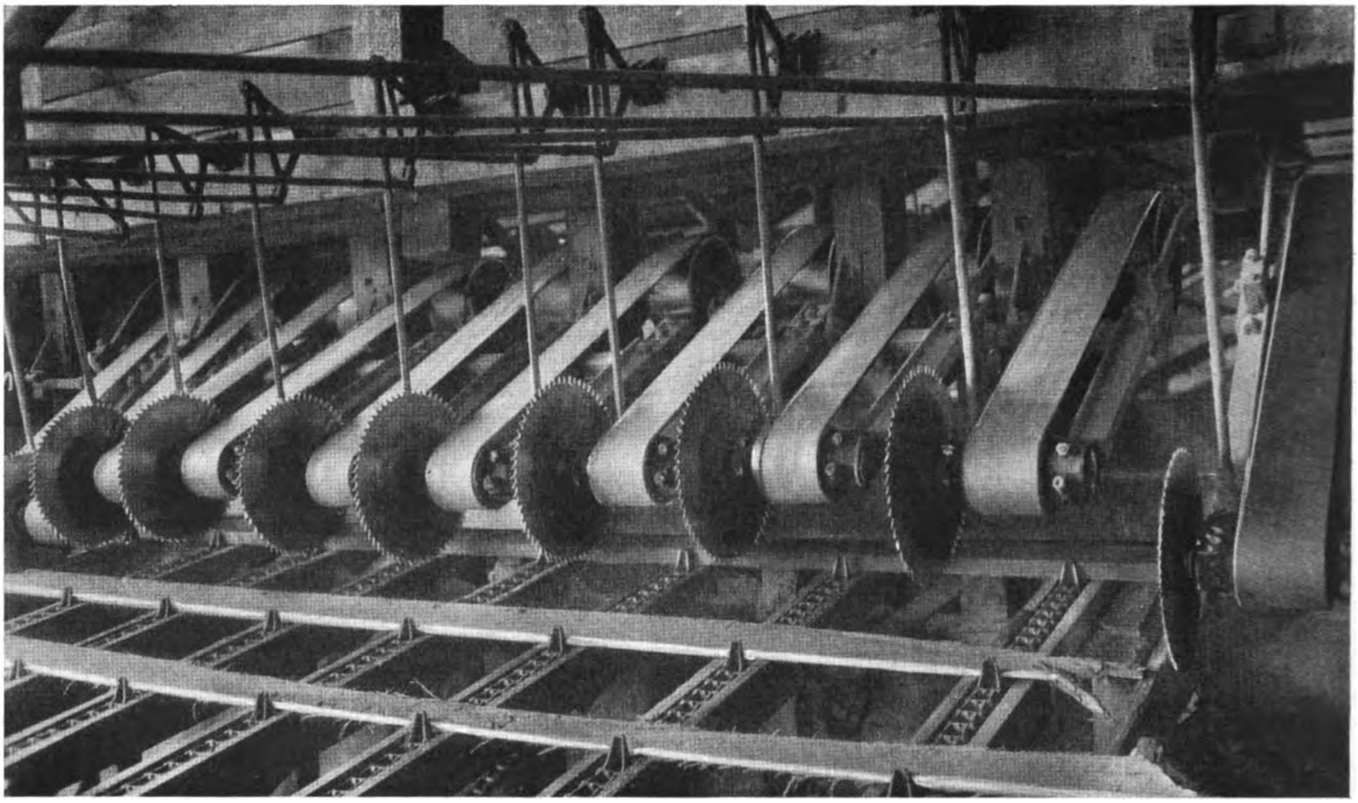
Silent chains are made up of special types of pins, connecting links so designed as to provide on the chain a tooth which fits into the tooth on the sprocket. They are in reality flexible racks; when straight, as in between sprockets, a chain acts as a rack and when passing over a sprocket acts as a reflex gear. It is similar in effect to two gears with about half their teeth in mesh except that the load is divided among them instead of being all on one tooth, as is the case with gears. The pitch of silent chains is the distance between the centers of pins in a chain. Sprockets do not have pitch dimensions, as do gears, but are designed to take chains of a certain pitch.

As is the case with other types of equipment, chain drives must be properly selected, installed, and cared for if the full benefit of the advantages which they offer is to be obtained. Properly-designed chain drives that are correctly installed and kept in good condition will operate quietly and efficiently, but if they are neglected or abused in any way, their life and efficiency will be reduced. In particular, attention should be paid to the lubrication of chain drives.

The manufacturers of block and roller chains, and of most silent chain drives, recommend that the chains be run in an oil bath, if the load is heavy or the chain is in continous operation. The wear on chains comes on the pins, between the chain and the teeth. There is also wear due to the rubbing of the sides of the links against each other in the constant bending and straightening out as the chain passes over the sprocket.

One important advantage that comes from the use of an oil bath is that all of the points where wear occurs are well lubricated. However, grease is frequently used on block

(Please turn to page 481)



Sawmill service imposes severe operating conditions which are well handled with belt drives. Here leather belts are used to drive each trimmer head at the W. T. Brown & Sons Lumber Company, Fayette, Ala. Lumber mills are large users of leather belts.

Recommendations on the

Application and Care of Leather Belt Drives

for industrial plant service, with a discussion of the factors that should be considered in the purchase and installation of this equipment

By J. R. HOPKINS

Chicago Belting Co., Chicago, Ill.

POWER-TRANSMISSION engineers in industrial plants frequently exercise great care in writing their specifications for shafting, hangers, hanger boxes, motors and machines, so as to obtain the most efficient equipment available, and will fight hard to frustrate any attempt to substitute other equipment merely to gain a price consideration, if it means a lowering of their standards of quality, efficiency, and serviceability. However, to many of these engineers, "a belt is a belt," and they requisition it by stating the length, width, and ply required, which gives the purchasing department a free hand to buy on price only.

The following example shows the fallacy of such an arrangement. The best grade of 4-in., heavy, single belt for, say, a $1,500 machine tool would cost about $24. Another belt of the same weight could be bought for about 10 per cent less, or a saving of $2.40. However, the output of the machine tool depends upon the power transmitted to it by the belt. In other words, the output of this $1,500 machine is jeopardized through the $2.40 saving on the belt, which is about ⅙ of 1 per cent of the cost of the machine and probably less than an hour's operating value.

A purchasing agent does not originate a purchase, but in many plants his only restriction when purchasing belting is the quantity needed of the different widths and plies. In many plants he is doing his work well. Purchasing agents have changed in recent years. Today they are more studious, more capable of being entrusted with technical purchases, and are of a higher grade generally. Few purchasing agents, however, know much about the severe requirements or on what machines the belts they buy are to go.

On the other hand, the engineer who has charge of the power transmission equipment, whether he is the electrical engineer, the master mechanic, or superintendent, has the authority to requisition whatever belting he wants. He could specify the belts and do a good job of it and be better off if he exercised that power; but he seldom does. As a rule he lets this right go by default because he fails to appreciate the importance of good belting in his transmission system.

Electrical power costs from $30 to $40 per year per horsepower. The power for a machine using 24 hp. and operating with a 4-in. belt costs $720 per year. The belt costs but $24. A saving of 10 per cent on the belt is only $2.40 on the first cost, which is less than ⅓ of 1 per cent of the power bill for that belt for a year. The average life of an oak-tanned leather belt is well over

8 yr. The power which the 4-in. belt transmits in 8 yr. costs not less than $5,760; so why save the $2.40? The cheaper belt may use at least 1 per cent more power because it may have to be put on the pulleys at a higher tension and use that much more power in the bearings, which would mean that during the life of the belt, the original saving of $2.40 would be responsible for a loss of $57.60 (1 per cent of the power bill), or more than twice the cost of an entire belt of first-class material.

A belt purchased at a saving of 10 per cent in first cost may cause extra shutdowns or require taking up more often and have to be replaced sooner. If shutdowns always occurred after the power was off it would not be so bad, but shutdowns usually come during productive hours and the men have to stand around and wait until the shop starts up again. So why should men in charge of power transmission not make it their duty to at least help out in the selection of leather belting? It is not necessary to take the buying power out of the hands of the purchasing department. However, it is to the advantage of the operating men to co-operate with the purchasing department and give them the benefit of their experience and knowledge. Purchasing agents are professional buyers; that is their job and they should do the buying.

The Responsibility for Belting Should Rest on One Man

The best way to handle the belting problem in any factory is to have one man in charge of the belting. It is desirable to have him and his assistants spend from one to three days in a good belt factory. In this way he can learn how to make laps, how to dress the belts, and how to make repairs. By seeing how belts are made he will have a better understanding of what he is doing and how to do it.

The belt man should requisition, install, take care of, and repair all the belts in the factory. If the plant does not have enough belts to occupy the time of one man he can take on other activities with his belt work. However, regardless of the number of belts, one man should be made responsible. If there are too many belts for one man he should have as many assistants as he needs. The belt man should have a shop or a bench where he can repair belts and do such other work as is necessary. The shop should be equipped with a bench and a handpress, and the man should be provided with the equipment listed in the box on page 468.

Belt Record—Card records should be kept of the performance of all belts. Suitable cards may be secured from belting manufacturers without charge. The card record should be kept on file in the office of whoever has charge of power transmission, where it will be available at any time. Each belt should have a separate card with spaces for a description of the drive and of the belt, when it had to be tightened, cleaned, dressed, the length of life of the belt, and why it failed. The purpose of the card record is to determine whether a belt is the best one for a particular drive, the merits of one manufacturer's belt compared with another, and the amount of care required by a belt. This information will assist in future purchases and will show how to correct present installations.

The belt man should watch the record of his belts on these cards, to see if any are stretching too rapidly or are requiring too frequent dressings and repairs. This will help him to correct unsatisfactory conditions. An oak-tanned belt should last for many years and if it has a short life, either the drive or the belt is at fault. Just before a belt is worn out and taken off, its record should be examined and before putting another belt on the drive, the belt man should decide whether any change in the machine or the type and size of the belt can be made to improve conditions.

Economy in the Use of Belting—The most important factor in true belt economy is to have the proper belt for every drive; that is a fundamental rule and should be followed religiously. The best way to determine this is to keep a card record over a period of years of the performance of all belts. Until such time as information is available from such records it is best to take the advice of reputable belting manufacturers regarding the belts and their reliability under operating conditions. The following points should be borne in mind in ordering a leather belt: (1) Tannage; (2) whether or not it is to be waterproof; (3) the number of plies; (4) width; (5) thickness; and (6) method of running—whether

This record card gives all of the data that should be known about a belt drive application.

Compliments of
Chicago Belting Company
Manufacturers of Leather Belting

Belt No ....
Dep: ....

BELT RECORD

.... Mill No .... Record made by ....

LOCATION	Date put on Date taken off
	Life of Belt
Drives	Tension lbs per sq in of Section
Length over Pulleys Cut to	Is Tight Side Top or Bottom H P
Width Thickness Ply	Crossed or Open
How Fastened	Cost of Belts
Pulleys-Driver D F. R P M to	Cost of Maintenance
Driven D F. R P M Vel F P M.	Total Cost
Maker Kind of Belt	Cost of New Belt

Date Taken Up	Amount Taken Out	Workman's Name	Time Repaired	Cost of Labor	REMARKS

MAKER	KIND OF BELT	SIZE	CUT TO	COST OF BELT	DATE PUT ON	DATE TAKEN OFF	LIFE OF BELT

Nothing takes the place of Leather

open, crossed, shifted, quarter-turn, and so on.

Tannage — Oak-tanned is the cheapest leather belt, will last the longest, and is recommended to be used wherever possible. Where moisture, steam or heat, or where considerable humidity comes in contact with the belt, and such a condition cannot be avoided, waterproof oak-tanned leather belting is recommended. Chrome-tanned belts are used where there are excessive heat conditions, excessive steam, acid fumes, or on very high speeds over small pulleys. Oak-tanned belts can be used to operate under heat conditions up to 135 deg. F., while chrome-tanned belts will stand heat up to 250 deg. F. All belts should be ordered with waterproof cement unless there is no moisture whatsoever to contend with.

Combination-tanned (so called because of the combination mineral and vegetable tanning process) leather belts are made essentially for use where the belts operate over three or more pulleys. Both chrome- and combination-tanned belts are more expensive than oak-tanned belts. It is important that all belts be made up with waterproof cement if they are to be used in a damp place, as moisture coming in contact with the ordinary cement causes it to soften and the laps and plies will soon open up.

Number of Plies—Practical rules to be used when deciding how many plies of leather to use are as follows: (1) Single belts should not be used over 8 in. wide. (2) Double belts should be used only on pulleys 6 in. in diameter and over. If it is necessary to use a double belt on a pulley smaller than 6 in. an especially pliable belt should be ordered; otherwise there is too much bending strain for the thickness. (3) Three-ply belts can be safely used on pulleys 20 in. in diameter and over.

It is best to use a double belt wherever possible on step-cone pulleys and shifter drives. A single belt does not have the thickness to stand shifting and the area of the edge that comes against the shifter is not great enough to keep the belt from curling. Never use a chrome or combination-tanned belt with a shifter; only oak-tanned belts should be used for these drives.

Length — When specifying length it is important to understand what is meant by endless belts. An endless belt is one that has its ends scarfed and cemented together. This method gives a joint practically as strong as the leather itself and is much superior to any joint in which fasteners are used. Fasteners or a lace makes holes in the leather and every hole in a leather belt reduces the tensile strength of the belt in direct proportion to the size of the hole. If a belt has a tensile strength of 800 lb. per inch of width, a ¼-in. hole will reduce the tensile strength 200 lb. In addition, fasteners and lace bump as they go around the pulleys and belts so fastened, if they do break, usually break where fastened.

All belts that can be made endless should be so joined. If a belt is to be made endless, the length around the pulley should be measured with a steel tape and the amount needed for the lap should be *added* to this. When ordering a belt from a belting company or storeroom it is safe to *deduct* ⅛ in. per foot in length from the total length required. This is to allow for the amount the belt will stretch when drawn up on the pulley.

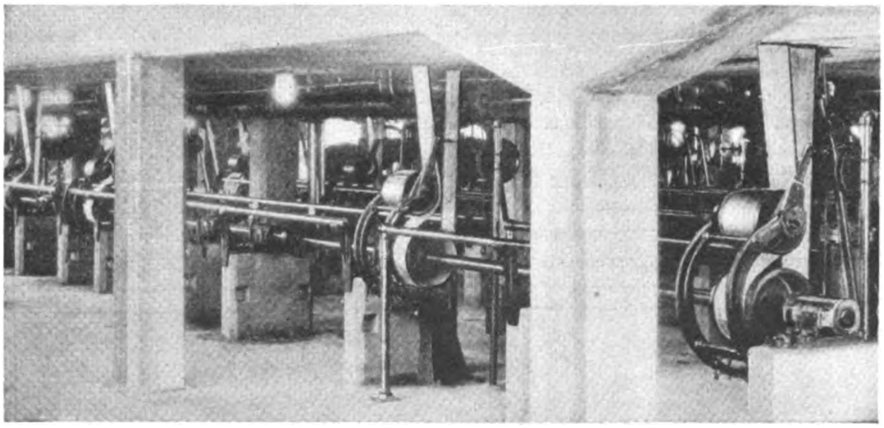
The belt should always be cut with square ends and it is best to use a carpenters' square as a guide for the knife. When ordering a special belt the following information as to length, measured by a steel tape, is required: (1) State on all requisitions, "Actual tape length around the pulley, with no allowance for stretch." (2) If a belt is to be made endless by the manufacturer state on requisition, "To be made endless, length does not include lap." (3) If the belt is to be made endless by the user after it has been put around the pulley, state on the requisition, "One end scarfed, length does not include lap." (4) If the belt is to be put together with lace or fasteners, state on the requisition, "Square ends."

Width—The width of the belt is, of course, limited by the face of the pulley. All pulleys should be at least ½ in. wider than the width of the belt. Frequently installations are found where the belt is too narrow to deliver the load because it is limited by the width of the pulley face. In such cases a heavier belt, or a belt with an additional ply should be tried. If the pulley is still too small for the heavier belt the drive should be changed so that the pulley will be wide enough for the belt or the diameter of both pul-

Things to Do to Get the Most from Belts

Men who are in charge of power transmission should:

Initiate the purchase of leather belts.
Have a belt man responsible for all belts.
Supply him with equipment necessary.
Make as many belts as possible endless by cementing the ends.
Inspect the belts regularly.
Secure open laps regularly.
Dress the belts systematically and at regular intervals.
Keep belt record cards.
Watch these belt cards.
See that the right belt is on each pulley.
If the belt now in use is too light for the load, put on a heavier one.
Know what makes a good leather belt.
Know how to buy it intelligently.
Remember: An ounce of preservation is worth ten pounds of cure in belt operation.



This lineshaft drives a large paper machine on the floor above.

In this case all of the drive belts operate from a single lineshaft. Sometimes a carefully synchronized motor is placed at each belt. On a paper machine, belts are frequently used to obtain sufficient flexibility to take care of the different grades of paper and the different speeds of the paper machine. This installation is located in the plant of the Crown Willamette Paper Company, Oregon City, Ore.

leys increased to give a higher belt speed and the narrow belt used.

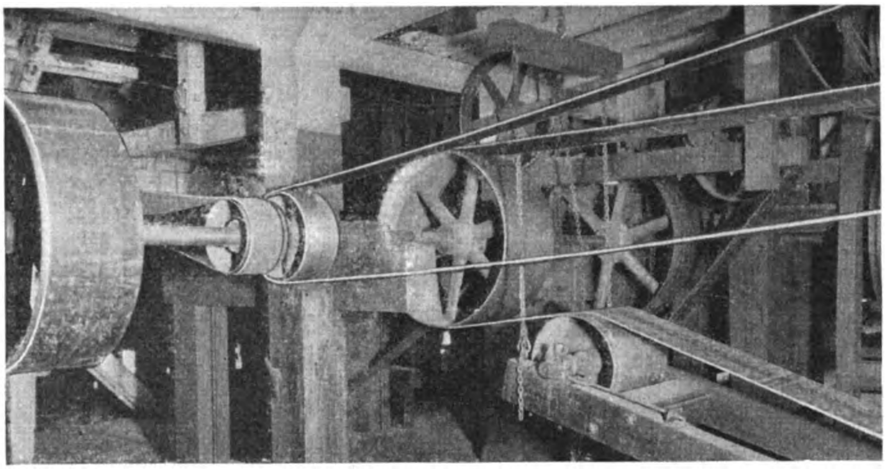
Length, width, and horsepower complications may be computed on a celluloid slide rule scale, which is furnished by The Leather Belting Exchange through its member companies. This slide rule is free on request.

Making Leather Belts Endless—Complete printed instructions for making leather belts endless are obtainable from leather belting manufacturers. These instructions are illustrated so that an ordinary workman with very little practice can become reasonably expert in making leather belts endless. Belts made with non-waterproof cement require only about 5 min. in which to dry. Belts made with waterproof cement require two coats, the first of which has to dry from 20 to 30 min. and the second of which has to remain in the belt press a similar length of time. For these reasons it is best to allow at least 1 hr. for making a waterproof leather belt endless.

Always place the hair or grain side of the belt against the pulley because the grain side transmits from 40 to 60 per cent more power than the flesh side. There are no exceptions to this rule, for running single belts. All belts should be run in the direction of the arrow which is stamped on the belt. This is so that the feather edge of the lap on the side next to the pulley will point away from the pulley as the lap approaches it.

Proper tension for putting on leather belts is 36 lb. per inch of width, per ply, per strand (every belt has two strands). A high-grade leather belt shortened ⅛ in. per foot in length and then drawn together will have approximately this tension. On a belt that is well stretched, future take-ups often can be eliminated by putting on the belt as tight as is possible. The majority of belts are put on too loose. The belt should be put on as tight as is possible without too much strain on the bearings, lineshaft and hangers.

Belt Cement—Always use a belt cement made by a high-grade leather belting manufacturer; never use carpenters' glue, as it is not suitable. When using ordinary belt cement it should be heated to a temperature of 167 deg. F. Do not heat up any more cement than will be used at one time, as it deteriorates on standing. If the weather is cold the leather should be warmed slightly by lighting paper and passing it over the parts to be cemented; otherwise the glue may cool before the ends can be cemented together because non-waterproof cement cools quickly. It is important that belt laps be brought together squarely and quickly after the cement is applied.



This belt drive is in the basement of the plant of the Good Pine Lumber Company, Good Pine, La.

Here a single lineshaft transmits the power through belts to machines on the floor above. The efficiency of such a lineshaft with modern bearings and the best leather belting is equaled only by large electric motors operating at full load. In many cases a higher efficiency can be obtained with mechanical power transmission equipment than with electrical.

After cementing, the laps should be rubbed down well with a smooth edge of a scraper and, if on a large belt, hammered for several minutes so that all air will be expelled from the joint. Although non-waterproof cement sets quickly, the belt should be allowed to stand as long as possible. It is good practice to permit newly cemented belts to stand from 3 to 6 hr. before using them. It is best to make a rule that a belt should never be placed on the pulley until at least 1 hr. after cementing and this soon only in emergencies. In hot or damp weather more time is required for the cement to set than when the weather is cool and dry.

After a belt has been taken off the pulley to be shortened or repaired a light coat of liquid belt dressing should be applied before it is returned to the pulley.

Belts that are to be put on with fasteners should have the ends squared carefully. The two ends are drawn up with the clamps in the same manner as when making endless belt. The two ends will overlap and the amount to cut out is marked on one end. This allowance should take into account the space taken up by the fasteners. The belt is then taken down from the pulley, cut to the exact length, and the fasteners applied. Rawhide laces are not widely used except on hand-shifted belts. As was stated earlier in this article, endless belts should be used wherever possible, as the holes required for lacing or other forms of fasteners weaken the belt.

Retightening Belts—Belts stretch more when new than after being used for some time and so it becomes necessary to tighten them to maintain the proper tension. The best stretched leather belting will not require more than one or two take-ups and after the stretch is all removed by actual running service no more take-ups will be necessary. Usually belts require tightening about three days after being put on. If a second tightening is necessary it usually comes about a month later than that. All belts should be inspected and whenever they appear to be too loose to do the work, should be tightened. Retightening or taking up a belt requires a little time, but it is well spent. When putting on a new belt, do not be afraid of putting it on too tight.

Examination During Service—Belting and drives should be inspected at regular intervals by the belt man; an examination of the card record will show when the inspection should be made. At these times the belt should be examined carefully. Once every two or three months should be sufficient for most belts, but between times the belt man should be on the lookout for trouble from unexpected sources. Dressing and cleaning the belt can be attended to as a part of the regular inspection.

Some of the points to look for and to do during the examination of a belt are as follows: If a belt lap starts to open up cement it down at once; don't wait for the belt to break. If a belt becomes dry, see that it is dressed. Have a regular plan for dressing belts periodically. It takes less time to do that than to do one repair job. Also, it requires less thought on the part of the belt man. If a piece of machinery or anything else rubs against a belt, remove whatever is doing the rubbing; otherwise it will wear out the belt. If a belt is operating under a condition where oil is constantly dropping on it, correct the condition. It is much more effective to stop the dripping oil than it is to try out belt after belt to try to get one that will run under such a bad condition.

Belt Dressing—Belt dressing still seems to be one subject on which most belt users want information. Leather belts should be dressed periodically every six months for the first year and at least every three months afterward. Belt dressing should never be of the sticky type as this destroys the belt. The best stick dressing today will stop slip instantly and also is good for the belt and prolongs its life.

Do not use castor oil or neatsfoot oil because they do not stop slip. A belt dressing that simply makes the belt pliable and does not stop slip instantly will not keep up production. The best belt dressing in either stick or paste form does not cost much and a comparatively small amount of dressing will keep a number of belts in good condition for a year.

Use a belt dressing that will penetrate the leather, as it is the interior fibers that need lubrication the most. Many belt dressings are surface dressings only. When applying a dressing spread on only as much as the leather will absorb. Do not put the dressing on too hurriedly, as it will tend to make the belt slip until the leather has absorbed it. Put on a little and then the slipping, if there is any slipping, will stop instantly. Then apply a little more at a time, several times if necessary. With all belt dressings be careful not to put on too much. It is better to put on too little than too much.

Many power maintenance men have only a smattering of knowledge of how to buy good leather belting and of what there is about belting that makes one leather belt last 10 yr. with only one take-up, while another may last only 5 yr. and have a take-up every year on the same drive. There is a great difference in the quality of leather belting. Any man who will take the simple steps to assure himself that he is buying the best leather belting, will secure results that will reward him amply for the time spent in a little study of the subject.

Equipment Needed by Belt Men

Belt clamps for putting on and retightening belts.
Electric gluepot and heater.
Glue brush.
Waterproof cement.
Non-waterproof cement.
Heel shaver, scraper and steel for sharpening same.
Belt knife, steel square.
Opening hammer.
Steel measuring tape.
Belt lacing equipment and supplies.

This list contains the essential items of equipment. Other tools and supplies may be added as the work increases.

Later on, if not right now, his opinion may be asked as to the relative merits of group and individual drives for some one of his shops. If he knows that leather belting can be secured that lasts for years with less than 1½ per cent slip and frequently less than 1 per cent, he can understand why a group drive of five belts driven by one 12-hp. motor may be better than, or at least entitled to consideration as a competitor of, five individual motors of 5 hp. each.

Some Recent Improvements in Leather Belting

To understand why leather belts are so efficient it is necessary to appreciate the improvements that have been made in leather belting in recent years. Today the best leather belting has a much improved surface. This is measured by the increase in the adhesion of the surface of the belt to the pulley face, which is a very important item in power transmission because the coefficient of friction of a belt is dependent on its pulley grip and its tension. The more a belt grips the pulley, the less tension is required. Where less tension is required, less power is used, because the power a belt will transmit is the difference between the tensions on the tight and loose sides. For this reason the adhesion of a leather belt is important. However, how many belt buyers can tell the adhesion factor of new belts coming into their plant?

Stretch in leather belts has also been improved in that some leather belts of today have about one-third less stretch than the best leather belts of 10 yr. ago. The best leather belting, from a maintenance point of view, is that which requires the fewest take-ups. Today, belting can be obtained that requires but one or two take-ups at the most. There is also a stretchless type of

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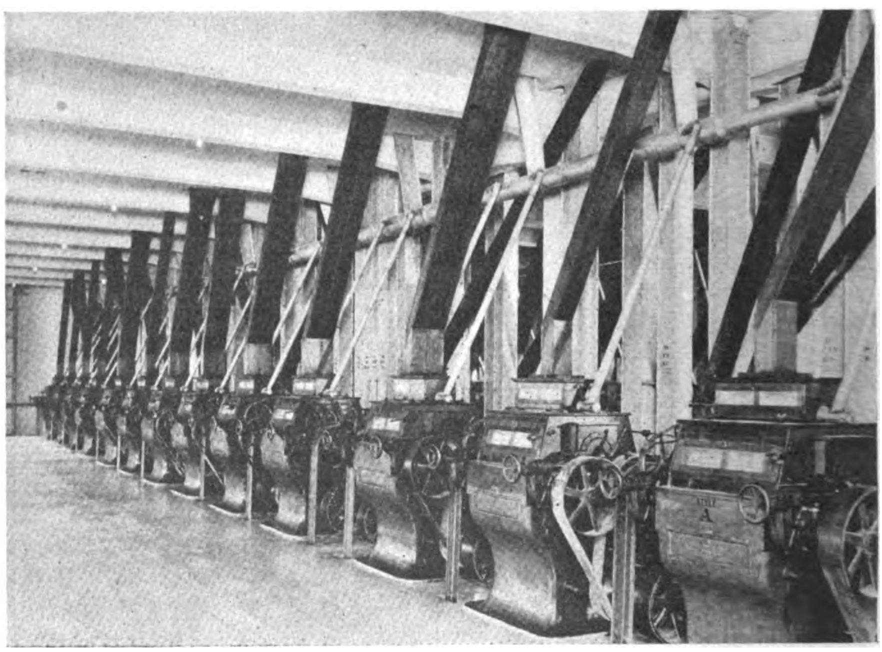
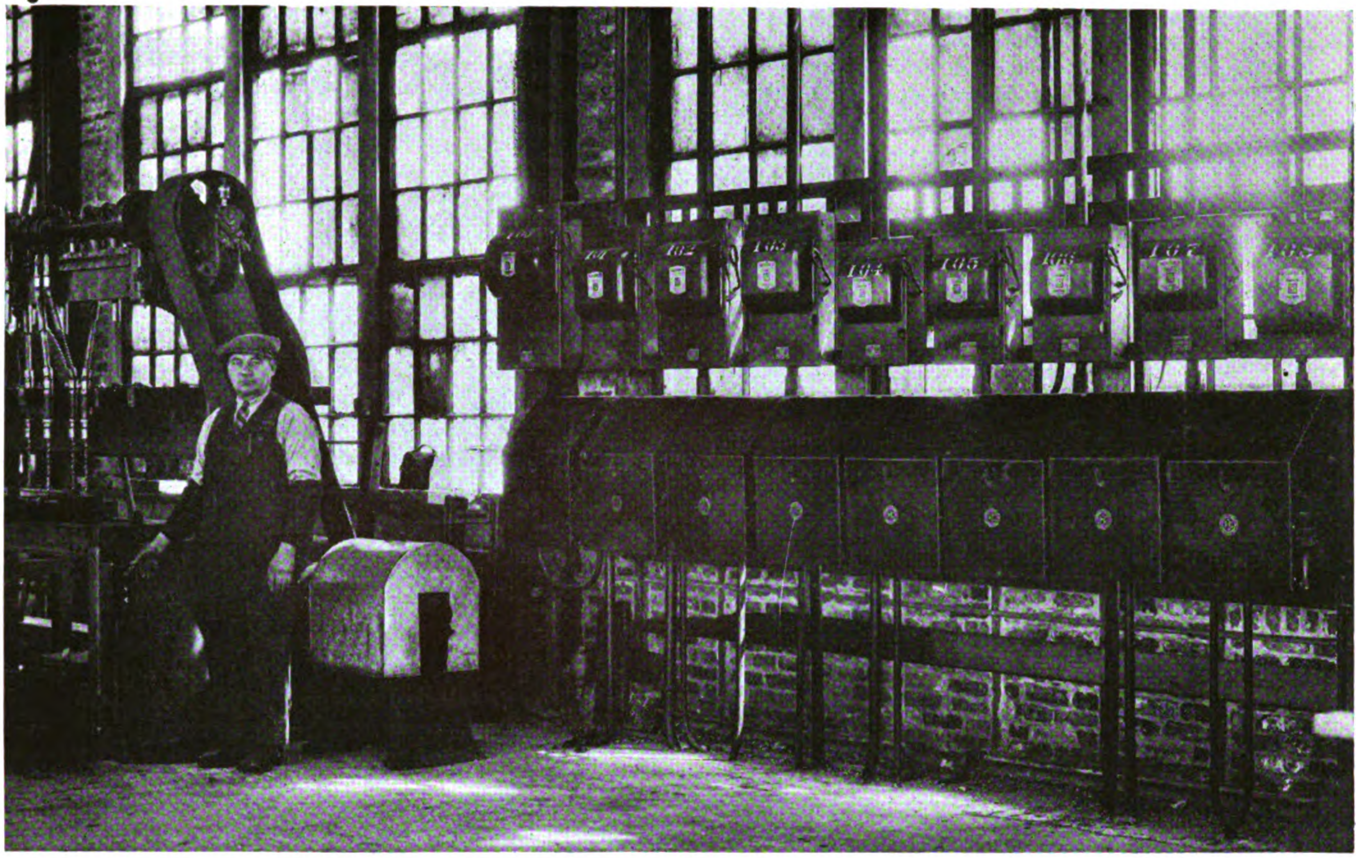


This line of rolls in a flour mill at the Kansas City Flour Mills, Kansas City, Mo., is operated from a lineshaft on the floor below.



Push-button control of motors is becoming more widely used in industrial applications. This installation of automatic compensators is operated from push buttons located at the individual machines. These compensators were made by the Industrial Controller Co.

"What Controller Should I Use for This Drive?"

By ARTHUR J. WHITCOMB
Associate Editor, Industrial Engineer

CONTROLLERS are the brains of power drives. They start the motor, stop it, reverse it, govern its acceleration and deceleration as well as its speed and protect it against damage from overload, undervoltage, single-phasing, and the like. Can we, therefore, in laying out power drives that are intended to stand up in severe service afford to slight the selection of the proper set of brains? A man may have a magnificent physique, yet without the proper mental balance his energy will be wasted in misdirected effort. Likewise, the power drive with a poor set of brains, will behave more or less like a lunatic, causing jerky starts, burning contacts, blazing fire at places unexpected by the average workmen and in general causing undue wear and tear on itself, the motor and the mechanical elements of the power drive connected thereto.

Industrial controllers exist in such an astonishing variety of types and forms as to confuse anyone not an expert in this field. The selection of the proper motor for a given service, apart from that of a special nature, is a relatively simple matter and concerns chiefly the power available, the work to be done, and the general conditions surrounding the installation. While this is usually given intelligent study, it is often true that the controller is chosen with less care and understanding. The controller for a motor driving a given machine ordinarily plays a very minor part in the cost of the complete installation, but its failure in any way to maintain service or secure the proper performance from the equipment will quickly counterbalance the false economy, which all too often is the main consideration in its selection.

To apply controllers intelligently to power drives requires a study of what the controller has to do and the various methods of accomplishing such results. Selection of a controller cannot be made by going through a list of the various types available in their countless combinations, but we can bring up one after another of the fundamental considerations and arrive at what we are searching for by a process of elimination.

The first consideration is duty. By this we mean the specific functions which are expected of the controller. These may be listed as follows:

(1) To start and stop the motor, either at fixed points in the cycle of operation or at the beginning and end of operation.

(2) To govern the acceleration and deceleration of the motor and provide proper accelerating and decelerating conditions.

(3) To control the direction of rotation.

(4) To control the speed of rotation.

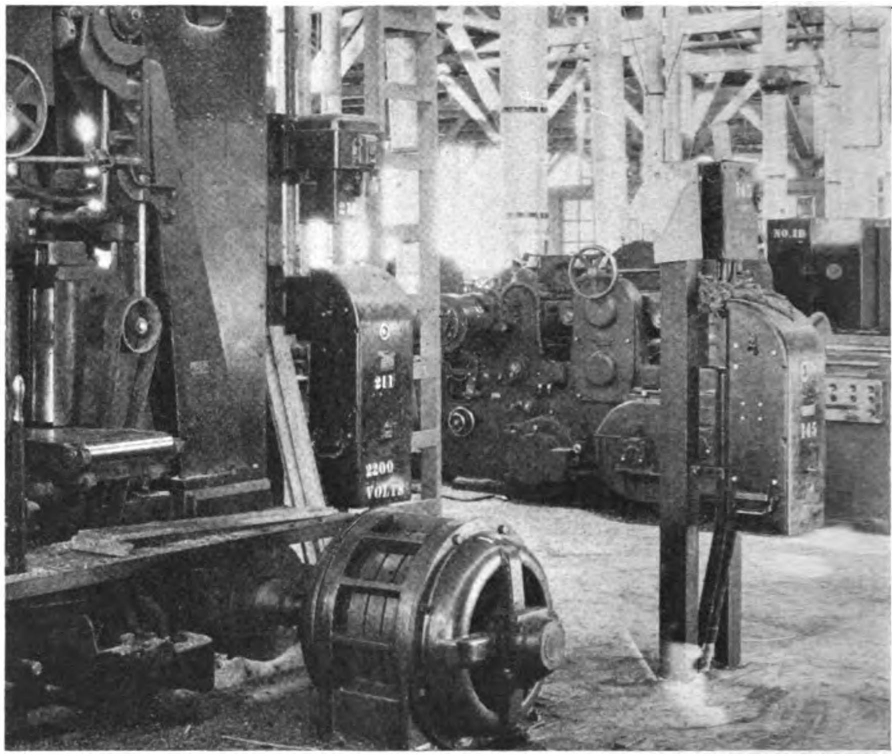
(5) To control the amount and direction of torque, and

(6) To control the flow of current.

The next consideration is service and by this we mean the specific application in which the controller is to be used, which includes: General Purpose, covering occasional starting

The compensator finds wide application for starting squirrel-cage motors.

The two compensators shown here are of General Electric manufacture and are in the plant of the Oregon-American Lumber Co. at Vernonia, Ore. These compensators are manually operated, but are tripped by pushing the button at the top of the compensator.



of motors; and Special Purpose, covering a long list of applications, such as rubber mills, cranes, elevators, steel mills, paper making, and the like, each of which demands some distinctive feature in the control in the way of capacity, specific functions and so on.

Another consideration is protection to motor and driven machine, included in which are overload protection, undervoltage protection, protection against too high current inrush and shock to machinery, protection against overtravel, overspeed protection, and protection against phase reversal, phase failure, and too sudden strengthening of motor field.

A feature that should always receive special consideration is safety to persons. These include protection against restarting of motor after failure of power, without personal intervention; enclosure of live and working parts against shock or burn; locking features to prevent operation of equipment while work is being done in inspecting or repairing; emergency stops to shut down the motor from any given point and to quickly stop it by braking or plugging, and devices to prevent overtravel or overspeed on elevators or other equipment handling dangerous material, such as molten metal.

There are also some conditions surrounding an installation which may require special protection of the controller. In the presence of an atmosphere filled with explosive material, gas, or acid, as in mines or chemical works, it is necessary to protect the controller against corrosion and against ignition of gas by arcs. It is also necessary in many cases to protect the controller from water.

In selecting the controller best suited for the power drive in question, convenience to the operator should not be overlooked. Particularly with machinery in which the work requires constant attention, it is important that the operator find the control within easy reach and manipulated with little care and effort. This brings up the question of whether the control should be of the automatic or manual types.

Having then determined what our controller has to do and what characteristics it must possess, let us consider the various types that are available. Electric controllers may be roughly divided into two general classes: those providing for manual acceleration of the motor and those providing for automatic acceleration. With the first class, the acceleration of the motor is entirely under the control of the operator, while with the second class this operation is performed automatically. An example of the first class is a drum or face-plate controller, while the magnetic controller is a good example of automatic control.

The earlier forms of control were manually operated. They were used on direct-current motors in railway and elevator service. These were very crude, but they have been developed until the modern manual controller is a thoroughly reliable and satisfactory piece of equipment. As compared with the automatic, magnetic type of control it has certain advantages and limitations which should receive due consideration when deciding what type of control is better adapted to the power drive in question.

The manually-operated controller is low in price as compared to the automatic controller, particularly in the small and medium capacities. It is compact, simple, entirely enclosed and can readily be made dustproof, spray-proof or gasproof, if necessary. It is strong mechanically, simple to operate, and easy to inspect.

On the other hand there are certain limitations of manual control that must be remembered when specifying the control for a given job. With the manually-operated controller, the operator must use discretion in not accelerating the motor too rapidly, thereby injuring the motor and driven machine. More trouble is usually experienced with arcing in this type of controller, thereby causing more rapid deterioration of contacts under severe service conditions and necessitating frequent inspection and adjustment of contacts. Also, for large motors there is a limitation in the size of manual controller that may be used, which is often objectionable when space for the master switch or push button station is limited, as on cranes and other applications. Also, the manual controller requires more effort to operate than the corresponding automatic controller, and often requires a separate protective panel to obtain overload and no-voltage protection.

Although automatic control is in general more expensive than manual control, it has many advantages that appeal to the operating executive. Probably the most important of these is the fact that push button control may be used, thereby permitting the use of operators who have no knowledge of electric equipment.

It is more "foolproof" than other types and may be located so as to in nowise endanger the operator. It may be provided with various safety devices. The automatic controller is characterized by positive opening and closing of contacts, which have long life, even though they are cheap and easily renewed. This type of control is strong and rugged, as well as easy to inspect when repairs or maintenance are required.

Also, this type of control permits the location of the master switch or push button at any desired point which may be at some distance from the controller. In other words, a large number of master switches may be located in a control pulpit, thus centralizing the operation of a large number of drives while the controllers may be placed at any convenient location.

However, against these advantages there are several limitations in the use of automatic control as compared with the manual type. Automatic control is more expensive than manual control. Also, the larger sizes occupy considerable space. In general, the wiring diagram is more complicated and requires a higher type of maintenance man to take care of it.

But even with these limitations the use of automatic control is becoming more widespread. The steel industry is a very good example. Many kinds of control have been developed in the heavy-duty service required by this industry. Beginning with crude manual controllers, this industry has progressed to the point where automatic control is almost the rule for the great majority of power drive applications. The main reason for this trend to automatic control in the steel industry is the fact that remote control is obtained by means of automatic control; the control master switches may be centralized, thereby permitting one man to control more operations, and because the control is automatic no consideration need be given the motor by the operator of the control. A feature that has increased the use of automatic control is the fact that better protection is given to equipment; the operator cannot abuse the latter. This is an important point, due to the progressively poorer class of labor that is being used in the mills.

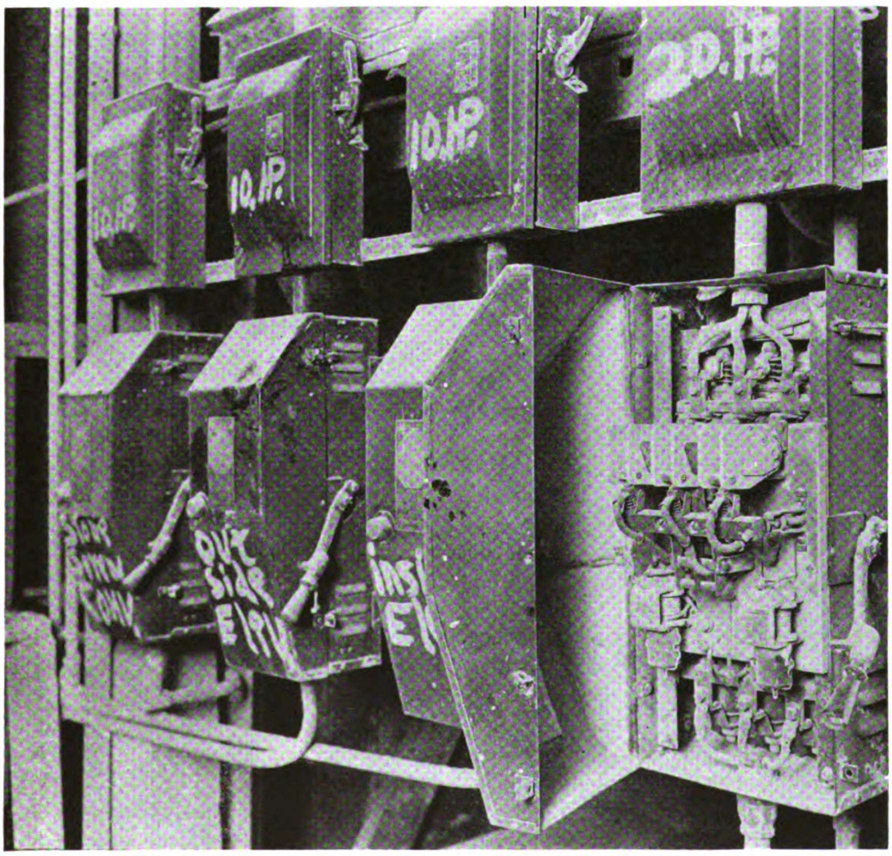
Another factor that is coming to the fore at the present time is the fact that in certain operations where drives must operate in sequence or on a certain cycle, the controls for the various drives may be interlocked so as to start automatically without an operator pushing a button. For this reason the past few years have seen a great reduction in the number of men required to operate a given mill.

Having weighed the relative advantages and limitations of manual and automatic types of control and having decided which type is best suited to the drive under consideration, the next step is to select the proper type of controller for the motor used on the drive in question.

Probably the motor in most common use today is the squirrel-cage induction motor. It is standard practice to start squirrel-cage motors in sizes up to 5 hp. inclusive by connecting them directly across the line by means of some form of starting switch. This same method is also permissible for larger motors providing that the starting duty is light, the driven machine capable of sustaining the sudden shock, and that the current peaks are not objectionable. However, the local public utility usually has some regulations regarding the size of motor that may be connected directly to the lines in this manner and these regulations must be consulted before finally deciding upon this method of control.

When using this method of control an across-the-line starter is used. It may be either manual or automatic. The manual type usually takes the form of a safety switch and is so arranged that the motor is thrown across the line without fuses, or with heavy starting fuses. After the motor comes up to speed the handle is thrown the other way so as to cut in the running fuses which are of the proper size to protect the motor against overload. There is also a manual, across-the-line starter which consists of an oil circuit breaker with definite time-limit, overload relays.

The automatic across-the-line starter consists of a magnetic contactor and some form of overload protection. The contactor is controlled from a push button switch which may be located at any convenient point. The important thing to consider is the type of overload protection provided. Inasmuch as



Another method of starting squirrel-cage motors involves the use of a primary-resistance starter.

These Allen-Bradley, manually-operated, primary-resistance starters are in the plant of the Kosmos Portland Cement Co., Kosmosdale, Ky. Moving the operating handle upwards connects the motor to the line and then by compressing the carbon discs which form the resistance, reduces the resistance to a low value, after which the magnetic contactors close, shorting out the resistance.

the magnetic contactor closes upon pushing the push button and no other connections are made, the overload protection must keep the motor on the line during the period the heavy starting current is taken and yet trip it off the line if an abnormal working load is encountered. This characteristic is provided for in the overload relay by arranging a time delay in the operation of the overload relay through the medium of a dashpot or, more recently, by means of a thermal element which does not operate to trip the motor until it has reached a certain temperature.

To reduce the shock of starting and to prevent line disturbances caused by excessive starting current being drawn, reduced voltage may be applied to squirrel-cage motors by several different forms of controllers. Probably the most common method involves the use of auto-transformers connected across the line with taps running to the motor. Several taps (usually from 50 per cent to 80 per cent) are brought out so that a choice of several starting voltages is obtainable. This type of starter is known as a compensator and can be obtained in both manual and automatic types. The usual manual type is equipped with a double-throw circuit breaker immersed in oil, so that the compensator handle is thrown one way for starting and after the motor comes up to speed, the handle is thrown to the opposite side, which action opens the starting contacts and closes the running contacts. In addition to this the compensator provides no-voltage and overload protection for the motor.

The automatic compensator is very similar to the manual type except that solenoids or magnets are provided for operating the starting and running switches. A definite time relay provides the necessary time interval between closing of the starting switch and closing of the running switch. In one type of automatic compensator, magnetic contactors of the air-break type are used instead of the double-throw, oil switch. This type of controller also uses a thermal overload relay, as well as providing no-voltage protection.

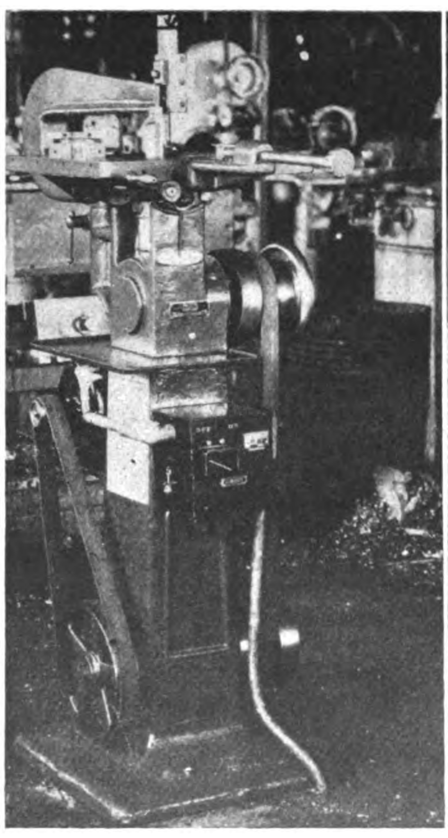
Naturally the automatic compensator is intended for remote control from a push button station that may be located at any desired point. The manual type cannot be arranged for this method of starting, but it can be stopped from a distant point by connecting a push button switch in the no-voltage release circuit. This is often done when one or more emergency stopping stations are necessary and also when the motor must be interlocked with some other drive, such as would be the case with a number of conveyor belts that are in series, one feeding the other.

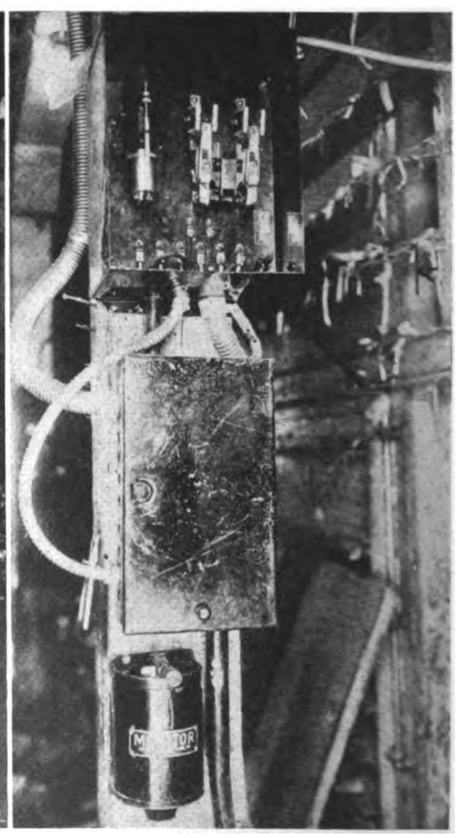
There are several advantages arising from the use of the compensator or auto-transformer type of starter. Reduction of voltage by transformer action avoids resistance losses, thereby causing a reduction in power for starting. Also, the line current taken in starting is less than the motor current in a degree depending upon the tap used. With a 50 per cent tap, the line current is only half of the current that flows through the motor winding.

Another method of starting squirrel-cage motors, which also meets with favor, involves the reduction of voltage by the insertion of resistance in series with the motor primary The amount of resistance may be adjusted to secure the desired starting voltage and torque. As the motor attains speed the resistors may be cut out in one or more steps. This method differs distinctly from the auto-transformer method in that the latter causes a reduced voltage of constant value to be applied to the motor, whereas the voltage at the terminals of a motor in series with primary resistors varies according to the motor current.

This form of control, which is known as the primary resistance method, is made in both manual and automatic types. One manual type uses tubes containing graphite discs for resistors. Pressure is gradually applied to these discs through a cam operated by a lever, thereby reducing the resistance. Slowly moving this lever from the *off* position to the *on* position connects the motor to the line through resistance and steplessly cuts out the resistance, leaving the motor across the line. The automatic type of starter is more commonly used with this method, however, and many controllers of this type use the cast-iron grid form of resistance with magnetic contactors cutting out one or more steps of it as the motor accelerates. Acceleration is controlled through a definite time relay or by a series relay actuated by the motor current. Overload and no-voltage protection are also provided.

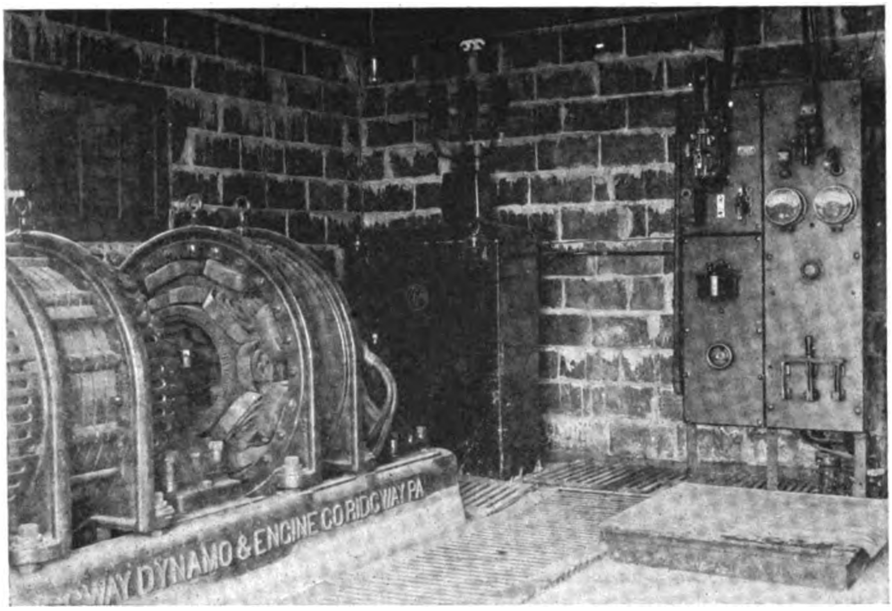
One of the advantages of this method of starting is that it is not necessary to interrupt the circuit in





Across-the-line starters are the simplest form of control for squirrel-cage motors.

In the center illustration is shown a Condit, manually-operated, across-the-line starter while at the right is shown a Monitor automatic across-the-line starter. This one is intended for reversing service on a paper baler and uses a drum reverse switch instead of a push-button switch.



This totally-enclosed synchronous motor controller is used on a motor-generator set.

The large steel tank in the corner adjacent to the d.c. generator contains the automatic compensator that provides reduced voltage for starting and also contains an automatic field switching panel for applying the d.c. field excitation to the synchronous motor. This control equipment was made by the Electric Controller & Mfg. Co. and is installed in an automatic substation. The d.c. generator is controlled from the switchboard shown at the extreme right of the picture and was supplied by the Automatic Reclosing Circuit Breaker Co.

transferring from the starting voltage to line voltage; consequently, interruption of torque is thereby avoided. This type of starter has a low first cost, is quite simple and is easy to repair. It also has a good power factor during the starting period.

Probably the newest type of squirrel-cage motor controller is the primay reactance type in which reactors, in place of resistors, are placed in series with the motor primary, as described in the foregoing. Otherwise it is very similar to the primary resistance type. This type of starter is marked by extreme simplicity and is very easy to adjust for the starting conditions desired.

Four types of controllers for squirrel-cage motors have been described, each of which is made in both manual and automatic types. Bearing in mind the differences outlined in the foregoing, selection should be based upon the characteristics that best fit the conditions on the drive in question. In addition to the foregoing it might be said that the across-the-line starter is the simplest and most reliable form and is preferable wherever conditions permit its use. Where there are limitations as to the permissible shock to the motor or drive, as well as line disturbance, one of the other three types must be chosen. This is usually the case when the motor rating is 10 hp. or larger. The relative advantages and disadvantages of primary resistance controllers and compensators is discussed at greater length in an article entitled "Operating Characteristics of Compensators and Primary Resistance Starters," published in the January, 1926, issue of INDUSTRIAL ENGINEER.

The characterictics of the wound-rotor motor are such that excellent starting performance may be secured by varying a resistance connected in the secondary or rotor circuit of the motor. A controller for this type of motor involves switching in both the primary and secondary circuits. The primary must be connected and disconnected from the lines in starting and stopping the motor and if reversing service is required the primary connections must be reversed. The secondary switching involves cutting out steps of resistance. The controllers for performing both of these functions may be manual or automatic. In the manual type the primary switching is handled by a carbon or oil circuit breaker, or if of low voltage, by some of the contacts of the drum controller or faceplate starter used on the secondary circuit. Where separate control devices are used for the primary and secondary circuits, some form of mechanical or electrical interlock is desirable to insure that the devices be operated in the proper sequence. When reversing service is required on low-voltage motors, a drum controller or faceplate starter handling both the primary and secondary circuits is more commonly used. When a separate primary switch is used, the low-voltage and overload protection are incorporated thereon. When the primary switching is done by the same device handling the secondary circuits, separate overload and no-voltage relays must be provided.

Automatic control for wound-rotor motors involves the use of magnetic contactors. These handle the primary and secondary circuits in proper sequence and also automatically accelerate the motor under the control of accelerating relays. A push button station or a master switch is used for starting and stopping the controller.

In addition to these types of control for the wound-rotor motor there is also the liquid controller utilizing plates immersed in an electrolyte for secondary resistance. This controller will not be described, for in this country it is principally used only on some of the larger sizes of motors.

In deciding which of the foregoing types shall be used on a given drive, consideration must be given to the size of the motor, voltage, and the frequency of starting and stopping. As the automatic controller is more expensive its use can be justified only when frequent starting and stopping are required, high voltage or large capacity handled, or remote control desired. Speed regulation can be obtained with either type of control on wound-rotor motors simply by cutting resistance in or out of the secondary circuit: that is, by stopping on any starting point that gives the required speed under load. In case speed regulation is desired, resistors having sufficient thermal capacity for this duty must be selected, instead of the usual starting-duty resistors.

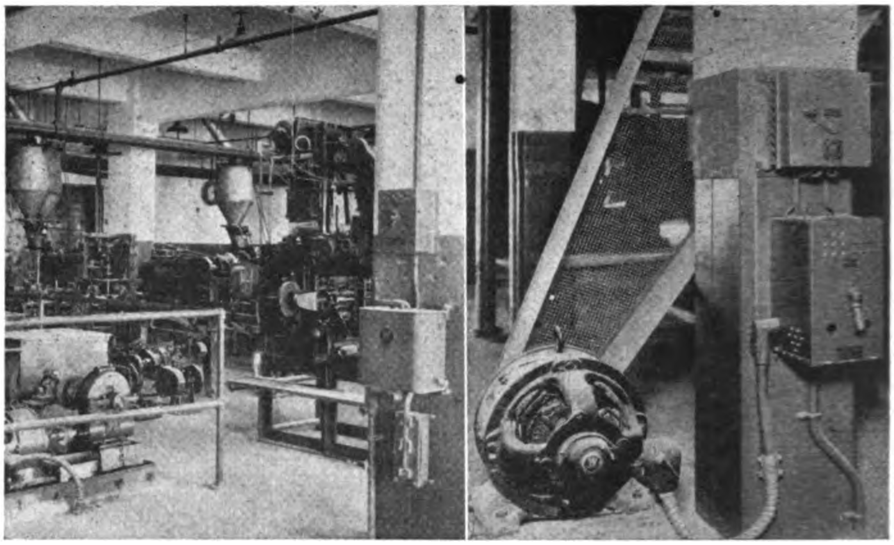
Practically all present-day synchronous motors are started by applying reduced voltage to the primary or stator winding. As the motor approaches synchronous speed, direct-current power is applied to the field winding and line voltage is applied to the stator winding of the motor. During the starting period it is essential that the d.c. field be closed through resistance so as to prevent the generation of high voltages in the field. Hence the controller for a synchronous motor should provide a means for connecting the motor primary across a reduced voltage and then across line voltage; a means

for connecting the fields across resistance during the starting period and to their direct-current source after the motor has accelerated; a means for adjusting the motor field strength; and instruments and protective features as required.

Control for synchronous motors is made in both the manual and automatic types. With the manual type either two oil circuit breakers or a double-throw, oil circuit breaker is used for applying the reduced voltage. A field switch, meters, and field resistors complete the control.

Due to the fact that more care and skill are required in starting a synchronous motor than is the case with a squirrel cage motor, automatic control is often preferred. In this type magnetic contactors or solenoid-operated oil circuit breakers replace the oil switches and a magnetic contactor replaces the field switch. To insure that the various switches close at the proper time a relay working either on the time element method or the field frequency method, or a combination of these methods, governs these functions.

Low-speed synchronous motors can be started by connecting them directly to the line. In such cases the starting kilovolt-amperes are about the same as required for a high-speed synchronous motor started with 65 per cent of line voltage. This type of starter subjects the motor to fewer current peaks, for there is no peak due to transfer from starting voltage to running voltage. When conditions permit line voltage starting, the control equipment is simplified and the number of contactors or circuit breakers is reduced.



Manually-operated controllers for direct-current motors.

At the left is a Westinghouse drum controller in use on a shunt motor driving a conveyor belt. At the right is a Westinghouse faceplate starter controlling a d.c. compound motor on a lineshaft drive. Inasmuch as neither of these devices includes overload protection, this is provided for in both cases by Urelite (Cutter Co.) enclosed circuit breakers shown mounted above and below the controllers, respectively.

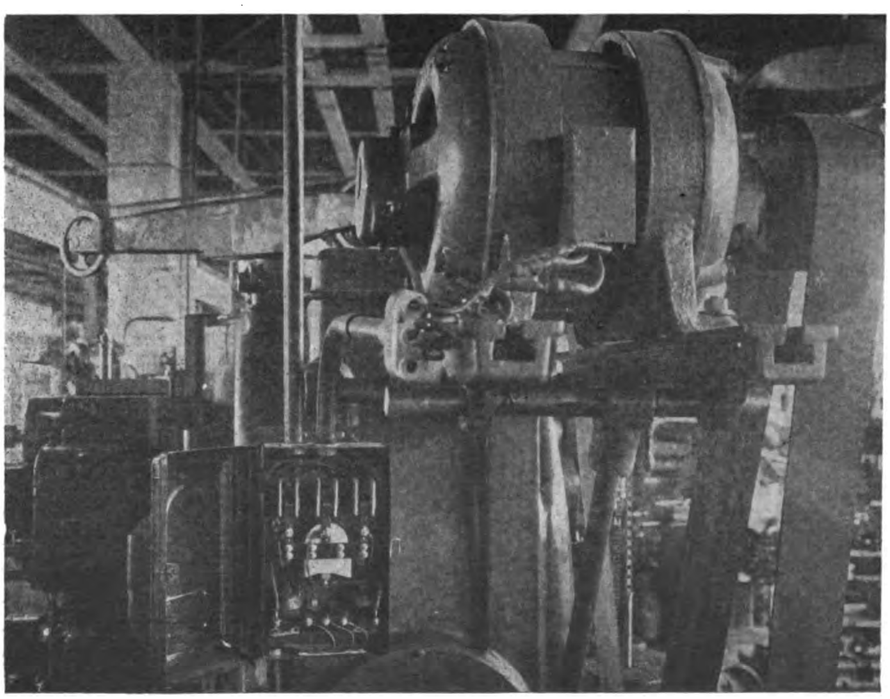
The decision as to what type of synchronous motor control to use must be based on the frequency of starting and stopping of the motor, the type of men who will operate it, the motor speed and capacity, cost, and the character of the load that the motor will have to start.

In the foregoing we have briefly treated the different types of alternating-current motor control with the exception of those used on single-phase motors. These will not be included in this article. Let us now consider the various types of direct-current controllers.

There are three common types of direct-current motors: namely, series, shunt, and compound wound, which differ from each other in the way that their fields are connected. The one requiring the simplest form of controller is the series motor. In this motor the armature and field are connected in series and all that is necessary for starting it, is to put resistance in series with the armature and series field. This is most commonly done by a faceplate starter, or drum controller in the manual type, and by a contactor panel in the automatic type. Some forms of drum controllers have segments revolving against fingers to make and break the circuit, while others have cam-operated contactors enclosed in a housing similar to the typical drum controller. The drum controller is commonly made for reversing service but does not provide overload or no-voltage protection to the motor. These must be provided for by means of a separate protective panel.

The faceplate starter is also used for series motors. In this type the segments are stationary and a revolving arm makes contact with them. This type of control must have separate protective equipment provided.

Automatic control for series mo-



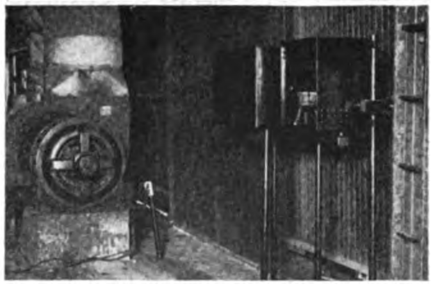
Across-the-line starter controlling a squirrel-cage motor driving a vertical turret lathe.

This Clark Controller Co. starter is operated from a push-button switch located at the front of the lathe, near the operator.

tors takes the form of panel-mounted magnetic contactors which connect and reverse the motor connections to the line as well as cut out steps of starting resistance. The closing of the resistance contactors is controlled by accelerating relays that are governed by the armature current or by time limit.

In selecting the controller for the series motor, it is mainly a question of whether manual or automatic control is required, which must be decided according to the advantages and limitations set forth at the beginning of this article. If the selection must be made from among the three manual types, it must be based mostly upon space requirements and individual preferences.

The shunt motor has its field shunted across the line so that the field is independent of the load current. This permits accurate speed control and it is on account of this characteristic that the shunt motor finds special application. The same types of controllers as described may be used with it except that provision must be made for adjusting the field strength if adjustable speed is desired. In many cases this takes the form of a separately-mounted field rheostat. In other cases the field rheostat can be combined in and operated by the drum controller itself. When an independent field rheostat is used it is necessary to provide a field-strengthening relay so as to prevent starting the motor on a weak field which would cause excessive sparking and probably a flash-over on the motor commutator. All shunt motors also require a field-failure relay, so that if the shunt field circuit opens, the motor will be disconnected from the line; otherwise it will overspeed and run away.



Combination of Rowan primary resistance starter and Urelite enclosed circuit breaker.

Here again the choice of the controller for a shunt motor simmers down to a choice between manual and automatic control. The manual type is mostly a matter of individual preference. In general, however, the faceplate type is used for non-reversing motors in the smaller capacities, while the drum type is used for reversing service and for the larger sizes.

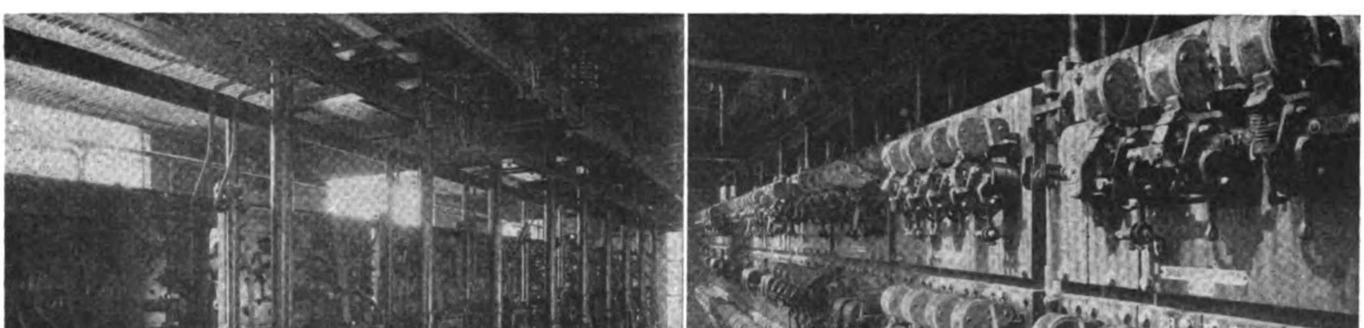
The compound wound motor is a combination of the shunt and series motors. It is ordinarily used for constant-speed service and for constant-speed drives that require considerable starting torque. The control for it is similar to that of the shunt motor, except that provision is not ordinarily made for adjusting the field strength and hence a field-strengthening relay is not required. The same considerations govern the selection of the controller for this motor as were mentioned for the other types of direct-current motors.

Besides the controllers for direct-current motors that have been mentioned, there are many special types. In the main these are automatic types and are intended for special applications such as cranes and hoists, printing presses, machine tools, coal and ore dock equipment, rubber mill equipment, steel mill applications, paper manufacture, and the like. It is not within the province of this article to discuss such special types.

Protective devices have been mentioned throughout this article. A word or two more should be said, however. Besides the overload relays that have been discussed, circuit breakers and fuses are extensively used for overload protection. A very popular form of individual motor circuit breaker is the enclosed circuit breaker that is opened and closed by levers located on the case.

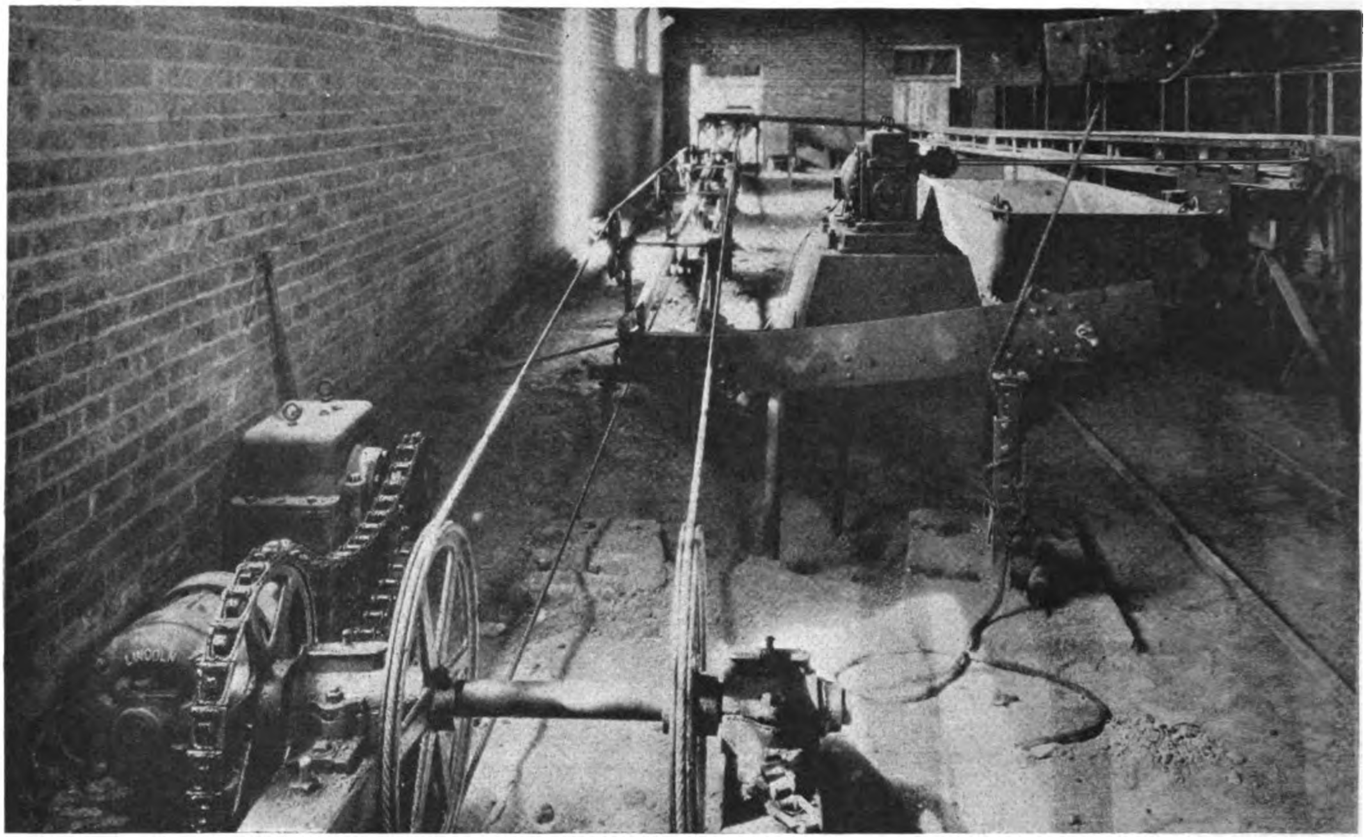
There is a temperature relay that may be attached directly to the motor and which, when the motor becomes excessively hot from overload or other reason, causes the motor to be disconnected from the load. We have already mentioned relays for protecting against no-voltage, field failure, and weak field. There are also relays for protection against over voltage, low voltage, phase reversal, single-phasing, overspeed and overtravel.

Such in brief is the field of controllers for general-purpose motors. The main thing to remember is that the controller is one of the most flexible elements in the power drive. It can be made to take care of many of the shortcomings of the drive provided consideration is given them at the time of selecting the control.



Here is an example of unusually good installation and housing of steel mill control.

This is part of an installation of 40 Cutler-Hammer inductive time-limit control panels. These panels are housed in a brick enclosure arranged on two floors, the upper floor being used for the resistors exclusively. Note in the left-hand illustration, the use of potheads on the conduits leading to the motors out in the mill.



This shows two worm gear speed reducers driving conveyors in a brick plant.

The reducer driving the cable conveyor at the left gives a speed reduction of 25:1 and is connected to a 1,740-r.p.m., 5-hp. motor. The worm reducer in the center of the illustration drives the conveyor at the right through a flexible coupling and long shaft. Horsburgh & Scott speed reducers are used here.

Examples of

Industrial Applications of Speed Reducers

together with a brief discussion of the various types of such units, how they are used, and the operating considerations involved in their selection

By **FRANK E. GOODING**
Associate Editor, Industrial Engineer

WHERE individual drives are used, it is often desirable to connect the motor as closely as possible to its load, particularly where it is not necessary to insert an elastic element in the drive to absorb vibration due to variable or shock loads. The development of the high-speed induction motor for industrial use introduced driving speeds which are much higher than the operating speeds of the driven shafts on practically all machines except some woodworking equipment and other high-speed tools. Manufacturers of machinery have not made a corresponding increase in the speed of their input or driven shafts. Where these machine drives had previously required some reduction, even with a slow-speed motor, considerably more reduction is now necessary. The effort to meet the demand for a compact unit, which would give the higher reduction ratios required, has resulted in the increased development and application of speed reducers or speed transformers, as they are frequently called.

In many cases, it had been the practice to use open gear trains or the open worm drive, often with cast or roughly cut teeth to obtain the necessary reduction. The higher speeds of the modern drive require better provision for lubrication and for keeping out dirt and dust, as well as more efficiently constructed and economically operated units for transforming the speed.

In general, four different types of speed reduction units, using gears as a reducing medium, have been developed. These are: (1) Worm gear reduction units. These consist of a driven worm or screw meshing in a worm wheel which it turns as rotation is imparted by the motor or other driving unit. (2) The compound or mill-type reducer, which is a series or train of plain or helical spur gears revolving on fixed centers and enclosed in a suitable housing. (3) The herringbone type, which is a modification of the spur-gear train, but uses double-helical or herringbone gears. (4) The spur-gear type with secondary gearing mounted at 120-deg. angles.

This fourth type of speed reduction equipment may be divided into three distinct groups and although the outward appearance is quite similar, each is different in its principle of operation, as is indicated by the accompanying sketch. These are: (*a*) The non-planetary type. This type of speed reduction unit employs a high-speed drive pinion meshing

with the three intermediate driven gears, which are journaled into the frame on fixed centers 120 deg. apart. These intermediate gears, in turn, mesh with and drive into a revolving internal ring gear, which is keyed through an integral web to the low-speed shaft. (*b*) The plain, spur gear type. This type of reduction is an adaption of the compound or mill-type (see 2 above) reducer. The secondary or intermediate gears are placed at 120-deg. angles to equalize separation strains on the drive pinion journal, and to distribute bearing strains on the secondary gear journals. (*c*) The planetary spur gear type. The planetary principle of speed reduction, as applied to speed reduction units, employs a high-speed drive or "sun" pinion, which meshes with and drives three intermediate or "planet" gears that are mounted at 120-deg. angles on the side of a free-running disk. These planet gears also mesh with a stationary internal ring gear which is integral with, or keyed to, the housing. when a rotative motion is applied to the sun or drive pinion, this motion is in turn transmitted to the planet or intermediate gears. The planet gears are journaled on a free running disk and, meshing as they do with the stationary ring gear, cause a rotation of the disk at a greatly reduced speed. The disk is keyed to the low-speed shaft (when used in a single-stage reducer) and transmits this reduced velocity to the low-speed shaft, and then to the driven machine or to a further reduction stage, when desired.

All of these various types of speed reducers are in common use and all are made with single and multiple stages of reduction. Each type has certain advantages, although all are widely used.

Where the ordinary gear train is used it is generally built into the machine. Where the bearings are not mounted substantially, or where the gear is mounted in the center of a long shaft with bearings at the ends, there may be sufficient spring in the shaft under heavy loads to cause excessive wear on the gear teeth. Gear trains should be enclosed so that they can be lubricated.

Worm gears of the single-reduction type give a right-angle, either horizontal or vertical, drive. This is of considerable importance in many cases for saving floor space, in that the motor can be placed alongside the machine instead of extending at right angles to the machine which it drives. This feature is noticeable in several of the illustrations in this article.

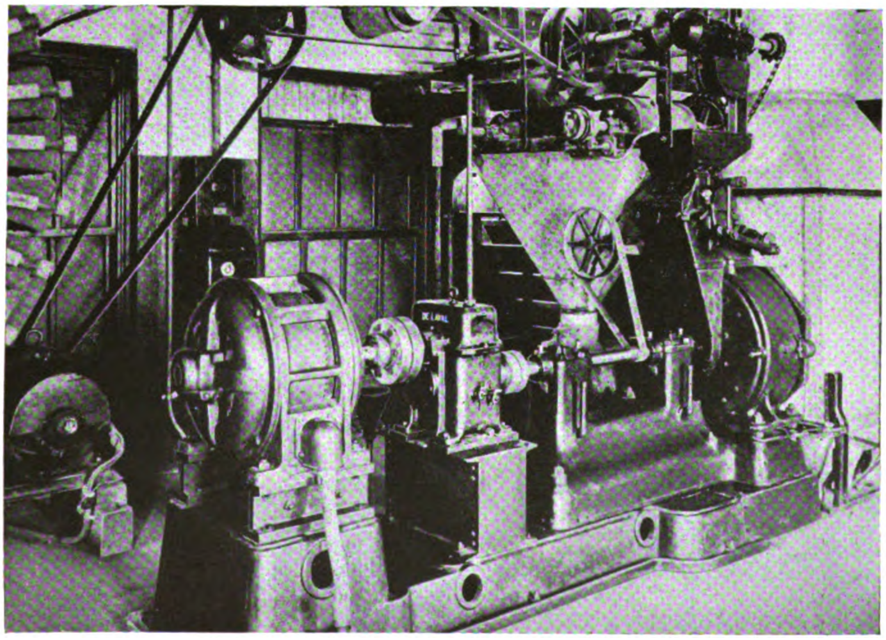
The present-day worm gear reducer must not be confused with the old type of worm which often consisted of a cast or roughly cut gear driven by a worm cut from ordinary steel. Worm gear reducers have been greatly improved within the past few years, until today many of them have anti-friction bearings, especially on the worm shaft, and improved methods of lubrication for both the gearing and the bearings. In practically all cases the worm operates in a bath of oil.

Improved cut worms of special alloy metals with modern bearings will operate at comparatively high speeds. The worm, naturally, has limitations on its efficiency in high reductions. Ordinarily, worm reducers are not made in standard units to deliver much above 100 to 125 hp. in the larger sizes under the best operating conditions of speed and reduction ratios. Enclosed spur gear reducers of the planetary, non-planetary and spur gear types are straight-line units; that is, the shaft of the reducer unit is attached to the end of the motor shaft through a flexible coupling and the two shafts are in a straight line. Where angle drives are necessary, the driving shaft of these types of speed reducers carries an enclosed bevel gear which drives the shaft of the reducer. This bevel gear gives a 90-deg. turn in the shaft.

In general reducers of all three gear types resemble a motor in appearance but are slightly larger or smaller, according to the type, than a motor of corresponding horsepower. The gears operate in an oil bath and some types are provided with anti-friction bearings.

Speed reducers are obtainable in standard units in a wide variety of reduction ratios. The manufacturer of these units makes standard shells or enclosing cases, each of which will take gears of fixed center distances. As it is possible to make gears with a larger number of ratios for each center distance, particular reduction ratios are obtainable by inserting various gears which will fit on these center distances. For this reason the ratios, as may be seen by consulting the manufacturers' catalogs, are in many instances, in decimal ratios. Thus, one manufacturer gives the ratio of a particular size of reducer as 10.285 : 1 or 9.643 : 1, instead of an even 10 : 1 ratio. However, many even ratios, and a 10 : 1 ratio in other sizes, are obtainable.

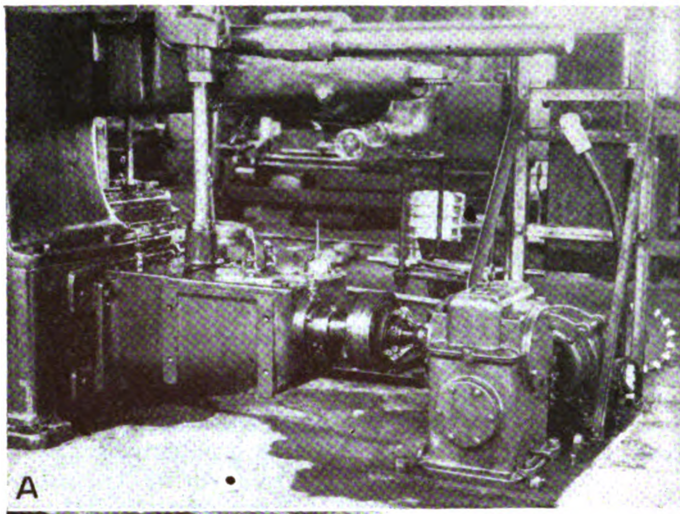
Different types of units have different standard maximum and minimum reduction ratios. However, manufacturers of the same type of equipment may supply units in different ratios so that the following statements on reduction ratios must be quite general. Examination of various manufacturers' catalogs indicates that standard reduction units are available in ratios approximately as follows: Herringbone reduction units: $1\frac{1}{2}$: 1 to 10 : 1, single reduction; 10 : 1 to 50 : 1, double reduction; and, 50 : 1 to 250 : 1, triple reduction.

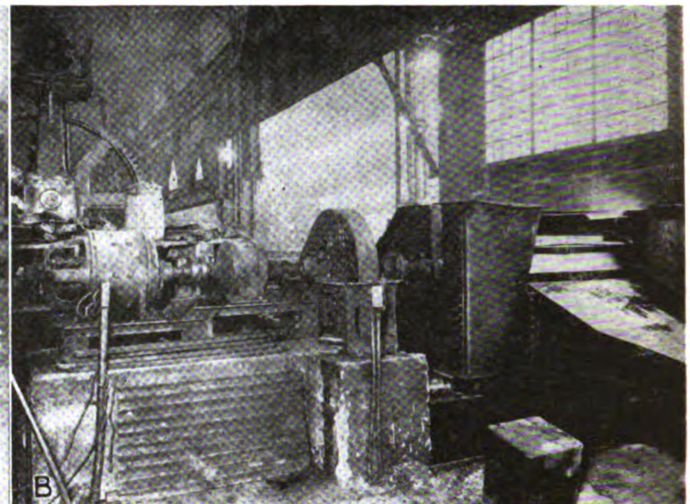


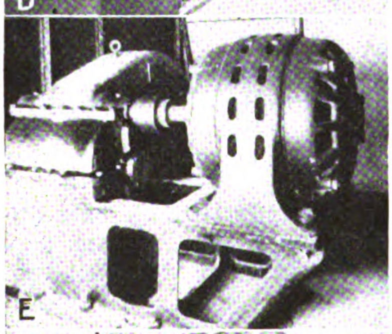
Speed is increased on this sugar pulverizer by connecting the motor to what would ordinarily be the low-speed shaft of this De Laval helical gear speed transformer.

Industrial Applications of Speed Reducers

How Different Types of Equipment Are Used in Ten Plants







A—Boring mill driven by a Cleveland 5½:1 worm gear from a 15-hp., 1,740-r.p.m. motor.

B—This James planetary reducer drives a conveyor through additional gear reduction.

C—Here a Winfield H. Smith worm gear reducer is used in combination with a chain for driving a conveyor belt.

D—A group of grinders individually driven through De Laval worm reduction gears.

E—Falk herringbone reduction gear and motor mounted for driving grain elevator head.

F—Combination of Foote worm gear reducers and roller chain drive connected to proofers and flour conveyors in a bakery.

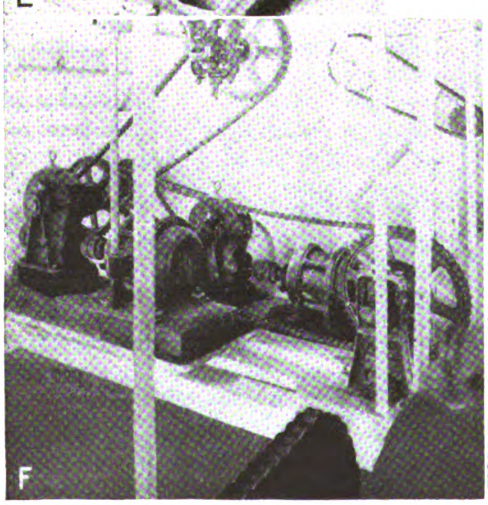
G—This shows the method of connecting a Boston worm gear reducer through chains and an additional gear reduction.

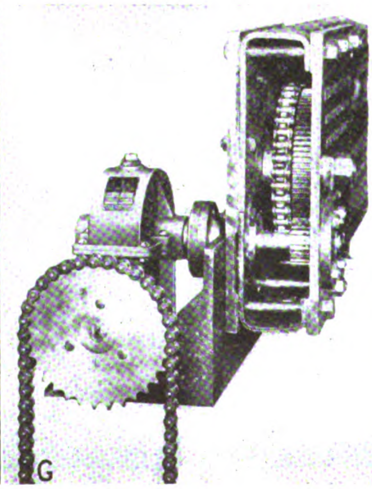
H—In this case a Lewellen variable-speed transmission is connected in between the motor and the Foote worm reducer in the operation of a pan conveyor in a bakery.

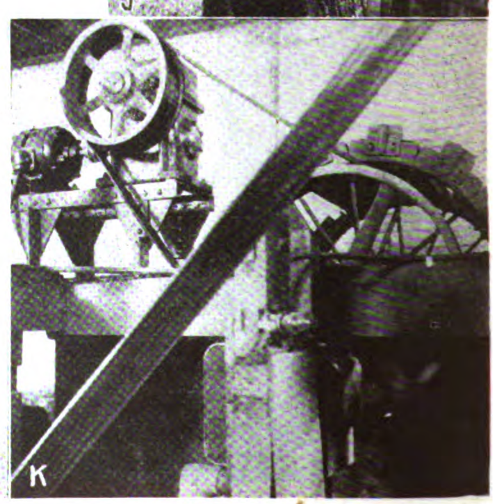
I—This Jones gear reducer is direct connected through gearing to drive a cement kiln.

J—Here the worm on a De Laval reducer is placed above the worm gear. This 17½:1 reducer is connected to a 25-hp., 860-r.p.m. motor and drives a cement elevator.

K—A severe type of service for worm gear reducers is caused by an overhung drive, as in connection with this Horsburgh & Scott reducer belted to a mold-washing machine in a brick plant.







Worm reducers: 7:1 with maximum depending upon output and decreasing with increased rating. Double-reduction worm units give reductions of 100:1 and up. Planetary: 4:1 to 200:1. Plain spur gear type: 3:1 to 200:1. Non-planetary: 4:1 to 100:1 and up in multiple reduction. It should not be assumed, however, that all of these reduction ratios are available in all capacities. The maximum ratings vary somewhat with the reducers made by the different manufacturers, and to a larger extent than do the minimum ratios. Special units, of course, can be built for other reductions. The manufacturer should be consulted on any special reduction problem and it is advisable to give him all the information possible regarding any particular installation, especially as to the service conditions, the horsepower to be delivered, the input and output speeds, and the type and horsepower of the drive and the machine driven.

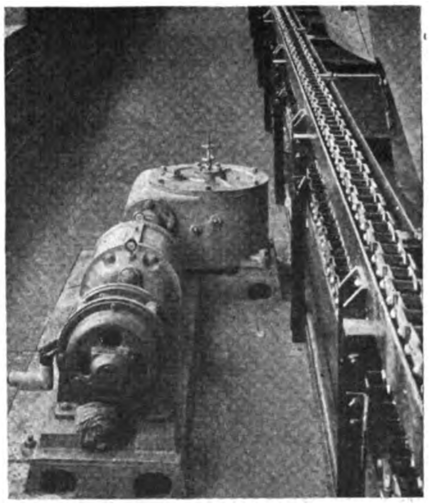
Worm Gear Speed Reducers Used for High Reductions

Higher reductions are usually obtained by combinations of worm and gear reducers, and there is practically no limit to the reductions obtainable in this way. Reductions up to 50,000:1 can be obtained through standard gear units, according to one manufacturer, and probably higher reductions could be obtained through the use of a double-reduction worm gear.

Herringbone reduction units alone are built for heavy power transmission. These units are made in capacities of several thousand horsepower. Other types of gear reducers ordinarily are seldom made much above 100 hp., although some units are made as standard equipment up to 250 hp. There is considerable controversy among industrial operating men regarding the relative merits of herringbone units and other gear reduction units within the field of both, from 50 to 75 hp. and up. Herringbone and helical gear reduction units are totally enclosed and the gears operate in an oil bath.

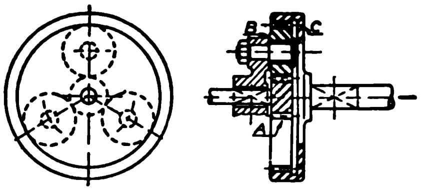
Extent of Industrial Applications of Speed Reducers

Speed reducers are used in practically every line of work where it is desired to reduce the speed from the driving unit to the driven unit in a fixed ratio. Probably the greatest demand for these units exists in

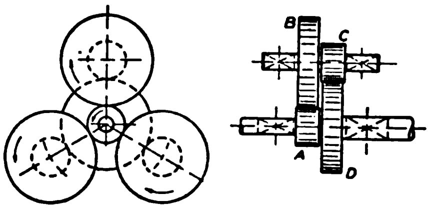


These Jones spur gear and horizontal worm gear reducers drive a conveyor on the ceiling of the floor below.

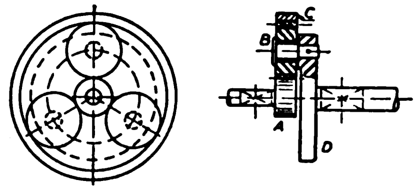
the cement industry where a large portion of the machines are operated at comparatively low speeds. Here the dust is such an important factor that practically any type of open metallic drive would be worn out very quickly. As all of these modern types of reducers are totally enclosed, the dust does not affect them. Also, under dusty surroundings reducers are frequently subject to neglect, but as practically all makes carry special provisions for lubrication, particularly on the gears, they require only infrequent attention.



A—Non-Planetary Type



B—Spur Gear Type



C—Planetary Type

This shows the arrangement of gears in each of the three types of gear reducers.

In all types the gears are enclosed in a circular case and mounted 120 deg. apart. The relation of the gears and their operation are different in each type. These types are: *A*, non-planetary type, *B*, plain spur gear type and *C*, planetary type. Each type is described in detail in the accompanying text.

Other important fields for speed reducers are in rubber plants, for the operation of the rolls, calenders and much of the other low-speed equipment. In chemical works, speed reducers are used in the operation of agitators, mixers, conveyors, grinding and rolling mills, and other equipment. Textile mills, coal mines, ceramic and brick plants, and steam power plants for operating auxiliary apparatus such as coal crushers, conveyors, stokers, and so on, also offer important fields for the use of speed reducers.

Nearly All Conveyors Require Speed Reducers

In addition, a large number of other industries use reducers to a certain extent. For example, practically every industry has use for conveyors which, if operated at very low speeds, frequently use a speed reducer of either the worm or gear type, or a combination of these. The assembly conveyor lines in automobile plants, for example, are generally driven by a motor through a gear speed reducer, a worm reducer and a variable-speed transmission. This not only gives the low-speed travel of the conveyor chain but also permits varying the speed to take care of increases or decreases in production demands.

An interesting application of a worm speed reducer is shown in the illustration at the beginning of this article. This is a Horsburgh & Scott series 1400, Type WB worm gear speed reducer driving a cable conveyor for loading brick pallets. This conveyor is driven by a 1,740-r.p.m., 5-hp. motor and the speed reduction is 25:1. The small floor space necessary and the generally compact arrangement are well shown in this illustration. Additional reduction is given to the cable conveyor through a link chain. Another worm speed reducer is shown in the center of this same picture. On this drive it was necessary to mount the reducer on a cement pedestal a considerable distance from the conveyor (at the right) which it drives through the single flexible coupling and shaft extending entirely across the track.

An interesting installation of a straight-line drive spur gear reducer is shown at the bottom of page 480.

This is a Type 4CA, 15:1 ratio, Albaugh-Dover, spur gear speed reducer operating at an input speed of 1,200 r.p.m. from a 40-hp. motor. In the illustration, the motor (at the right) is shown covered by a sheet-metal helmet to protect it against moisture. This reducer is driving a 16-in. spiral conveyor 70 ft. long in a mill producing special ground feeds. The conveyor is fed by 13 presses and operates continuously the year around. Should any units in the drive fail for even a short period of time it would mean the stoppage of the entire plant. This unit is equipped with alloy steel gears mounted on 10 heavy-duty self-lubricating roller bearings.

Where it is desired to employ an angular drive, angular gear reducers are used, as shown on the top of page 481. This is a Ganschow planetary reducer unit driving conveyor heads in a cement mill. In this case a straight-line drive would have extended the motor into the aisle and the angular drive saved considerable floor space. The angle may be changed so that the reduction drive is vertical and either up or down.

Speed Reducers Can Be Used for Stepping Up Speed

In some cases reversed connections are made to the speed reducer and it is used for stepping-up speeds. An example of that is shown in connection with the sugar pulverizer illustrated on page 477. This is a De Laval single-stage helical gear reducer connected in with flexible couplings on each side of the speed transformer.

The Falk herringbone speed reducer in the foreground drives the conveyor on an automatic sorter in a large lumber mill.

Considerable care must always be exercised in using speed transformers for stepping up speed to see that the ratio is not too high, because the operation of stepping up speed with a transformer is very much like trying to lift a weight with the short end of a lever. Also, obviously, as the reduction increases the torque would necessarily decrease. This is the reverse of the condition when stepping down speeds in that the torque increases as the speed decreases.

An interesting combination of speed reducer units is shown in the illustration on page 479 of the Jones reducers in an automobile plant. This shows a Jones No. 12, double-type, style 1 spur gear speed reducer with a 56:1 ratio connected to a Jones No. 14 horizontal worm gear speed reducer with a 35:1 reduction ratio driving a conveyor on the floor below. This unit is driven by an 1,800-r.p.m., 1-hp., induction motor.

The left-hand illustration below shows the use of a Foote non-planetary speed reducer which drives a rack on a transfer table for loading and unloading or pulling annealing furnaces. The single transfer table serves both furnaces.

A number of other installations are shown in other illustrations in this article and in the special page of photographs on page 478. A description of each accompanies the illustration.

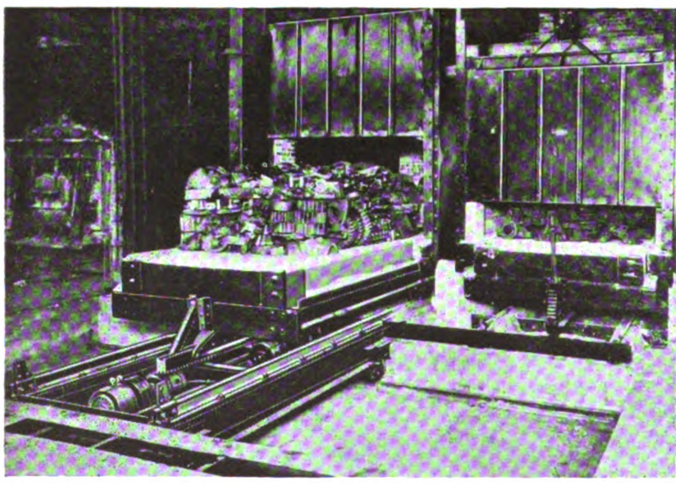
Operating Conditions to Consider When Using Speed Reducers

It is always advisable to use a flexible coupling in connecting the motor to the speed reducer, because of the difficulty in maintaining perfect alignment. Also, the unit should be mounted on a substantial foundation.

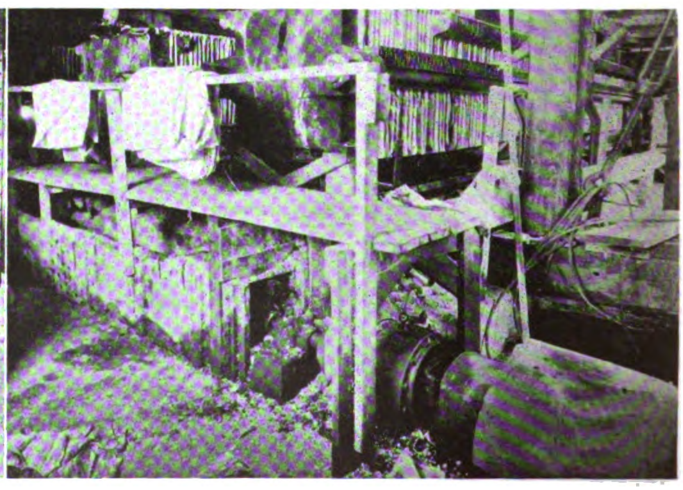
Practically all manufacturers of reducer units will supply cast-iron foundation plates or bases on which the motor and its reducer may be mounted. It is advisable to mount this base on a substantial concrete foundation.

One point which is frequently overlooked by users is that in selecting a speed reducer for any particular service, careful consideration should be given to the power output of the reducer or, in other words, to the power required to drive the machine.

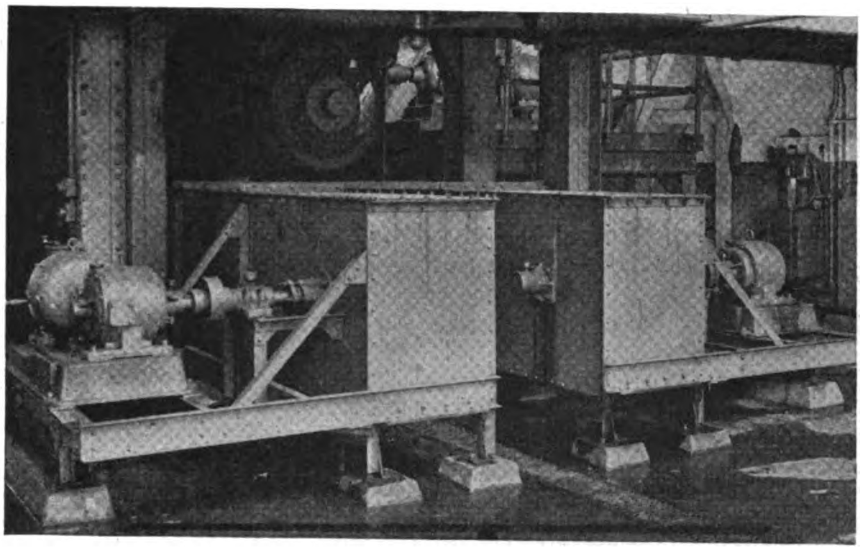
However, many users consider it necessary merely to specify the reducer unit from the standpoint of the horsepower and speed of the motor drive and reduction ratio only.



A Foote non-planetary gear speed reducer helps to fill and pull these annealing ovens by driving a rack in the transfer table.



Here a spiral conveyor, 70 ft. long, is driven by a 1,200-r.p.m., 40-hp. motor through a 15:1 ratio Albaugh-Dover spur gear speed reducer.



Although gear reducers are usually straight-line transmissions, this Ganschow planetary reducer connected to conveyor heads is a right-angle drive. This change in direction is obtained by means of bevel gears in the reducer.

Also, users should remember that the type of service and the operating conditions have a great deal to do with determining the proper size of drive, the same as with any other mechanical unit employed in power transmission. Severe operating conditions necessitate giving special attention to the use of service factors in selecting a unit of the proper rating.

It would be well worth while for users to take advantage of the opportunities of consulting with the manufacturers of the reduction units regarding an installation, rather than try to order from the catalog.

Quality of manufacture is also a very important point in speed transformers. This becomes more important with the severe service conditions and increased power and speed that are the order of the day. For that matter, quality is a point to be given very careful consideration in connection with any equipment.

Editor's Note: Acknowledgment is made to the following companies for information and photographs used in this article: Albaugh-Dover Mfg. Co., Chicago. Ill.; Boston Gear Works Sales Co., Norfolk Downs, Mass.; Cleveland Worm & Gear Co., Cleveland, Ohio; De Laval Steam Turbine Co., Trenton, N. J.; Falk Corp., Milwaukee, Wis.; Fawcus Machine Co., Pittsburgh, Pa.; Foote Bros. Gear & Machine Co., Chicago, Ill.; Wm. Ganschow Co., Chicago, Ill.; Horsburgh & Scott Co., Cleveland, Ohio; D. O. James Mfg. Co., Chicago, Ill.; W. A. Jones Foundry & Machine Co., Chicago, Ill.; R. D. Nuttall Co., Pittsburgh, Pa.; Winfield H. Smith Co., Springville, N. Y.

Reducing Friction Losses

(Continued from page 463)

or roller chains, and on some silent chains. As a matter of safety to the workmen, as well as protection to the chain, it is always well to have chain drives enclosed. More detailed information on the selection, application, and lubrication of chain drives will be found in articles which appeared in the July and September, 1923, and the March, 1925, issues of INDUSTRIAL ENGINEER, and on page 456 of this issue.

There has been a general tendency during the past few years to use higher lineshaft speeds. For one thing, this permits the use of high-speed motors, which are more efficient and less costly than low-speed motors. Operating lineshafts at higher speeds than were formerly used does not require so great a reduction in speed between the motor and the lineshaft. Consequently, better pulley ratios can be employed. In some recent installations in which high lineshaft speed is either desirable, or at least not objectionable, short lineshafts have been coupled directly to the driving motor, which turns at 1,200 or 900 r.p.m. This method of driving a shaft makes it possible to eliminate at least one belt and reduces correspondingly the friction on both motor and lineshaft bearings.

In some other installations in which it was not feasible to drive the lineshaft at the speed of the motor, a speed reducer has been used between the motor and the lineshaft. In this way the advantages of a direct drive are obtained.

Precautions to Be Followed in Welding Cans, Barrels or Tanks

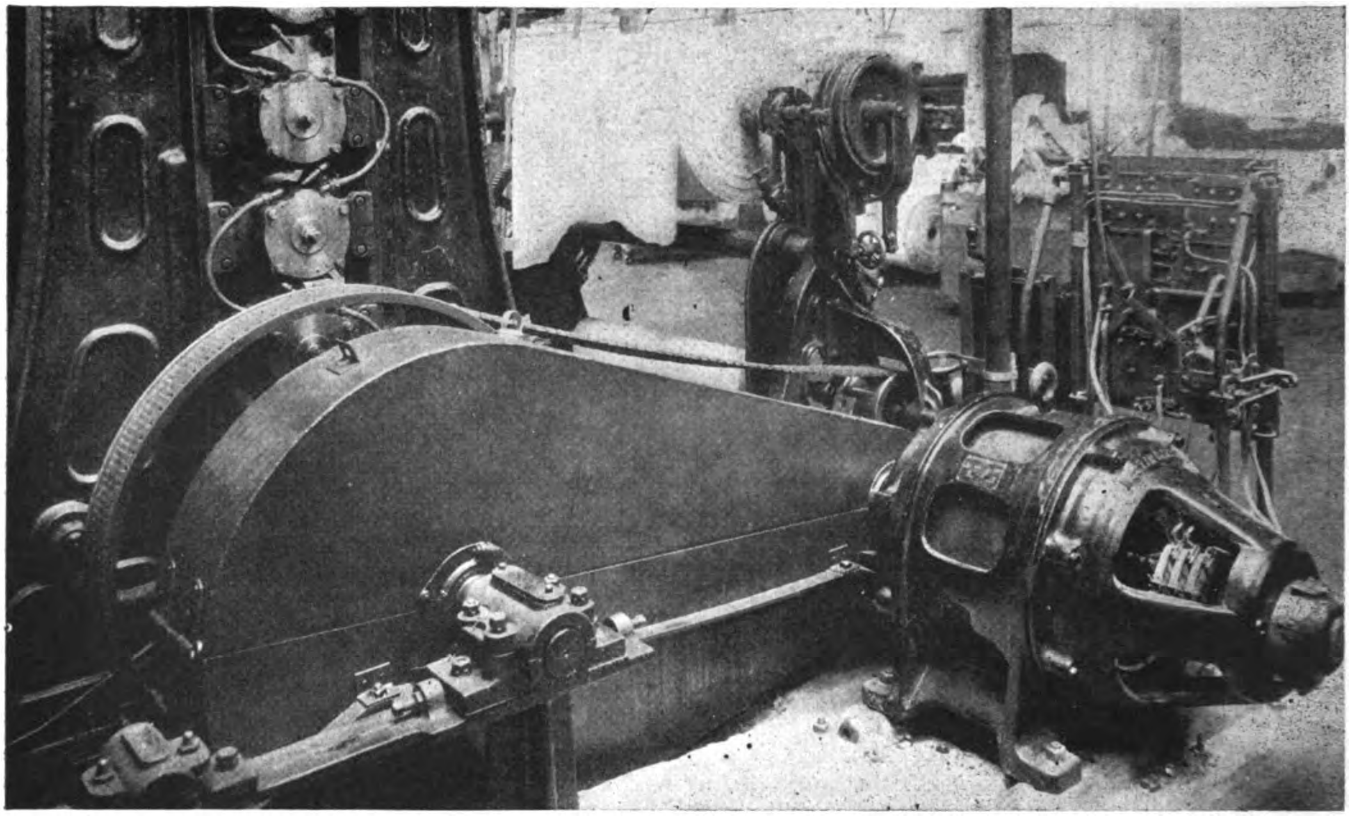
REPAIRING, adding fittings or altering metal tanks, barrels, or drums, requires the taking of special safety precautions. A large proportion of these containers have been used to hold oil or other liquids which, under the action of the welding heat, may catch fire, or even explode.

Two precautions should always be taken in all cases, according to recommendations of The Linde Air Products Co., New York City: The container should be thoroughly cleaned and also vented to prevent the accumulation of gases under pressure due to the heat of the welding. It is well to make it a rule to clean every container before welding, regardless of what the operator *thinks* that it may have formerly contained.

Live steam will effectively remove traces of oils or liquids, such as gasoline and so on; scrubbing with a lye solution will take out oily materials. There are also a number of special cleaning preparations which may be used. One of the easiest and safest ways of protecting the operator is to flush the container thoroughly with water, then to turn it so that the damaged section is uppermost, and fill it with water nearly up to the defect. The unfilled section of the container should be vented, however. The welding can then be carried on with the least possible open space inside.

This precaution applies not only to welding, but to other repairs. Even a blow from a hammer may strike a spark or friction may generate enough static electricity to cause an explosion if inflammable vapor is present.

Handhole or other fittings should always be opened before beginning the cutting or welding operation, as these openings provide means for the release of heated air. It is safest to take every possible precaution to prevent air or gas pressure from building up inside tanks or barrels when the flame is applied to the metal. It is not safe to take the chance that no liquid which may cause gaseous vapor has got into containers unsuspectedly. It takes time to fill a tank with water, but not nearly so much time as some men in a hurry have spent in a hospital.



When bearing pressures are high, a reliable and efficient method of lubrication must be used.

In this paper mill installation, use is made of a forced-circulation lubricating system, in which the oil is circulated through the bearings, cooled, filtered, and returned to the bearings. In this instance the chain drive between the motor and the machine is enclosed and operates in a bath of oil. The chain is thus protected and thorough lubrication assured.

Progress made in

Lubricating Power Drives in Industrial Plants

through the development of better lubricants and improved methods of application that have been necessary to meet changed operating conditions

ONE of the most outstanding features indicated in the combined progress of lubrication and mechanical developments during the past few years is the demand in many classes of industry for higher speeds. Highly-developed competition, characteristic of modern industry, is responsible for the necessity for greater production with a minimum of increase in operating expense. Without increasing the cost of equipment or the overhead expense involved in larger equipment, the speeding up of machinery constitutes one means of increasing production.

This tendency is evidenced not only by the improved design of new machinery being built and installed, but also by the rehabilitation and improvement of old machinery to meet the requirements of modern industry. Equipment that was built for the conditions of a more leisurely production period is constantly being operated at approximately the speed of newer types of similar equipment.

This change has been met both by a recognition on the part of the designers of equipment and by increased attention to the improvement of conditions on machinery already in service. Speeding up of equipment depends primarily upon the efficiency of lubrication of the bearings, gears and other parts of the machine, because it is upon the proper functioning of these that the strain of extra production falls.

A machine, for example a paper machine, may operate at a speed of 800 f.p.m., for which speed the bearings and other parts have been correctly designed. Conditions may demand that the paper machine produce at the rate of 1,000 ft. of paper per minute, or even more. This would require the introduction of an additional factor of safety to make up for the burden of the overload imposed by the higher speed.

Parts of machines first affected by any increase in speed are naturally the bearings, gears and other frictional surfaces. These must move at a more rapid rate and more heat will be generated by the higher rate of motion. Therefore, some means must be introduced to provide better lubrication, a more efficient lubricant, and to insure its application regularly and positively, in order to offset the increased speed. These changed conditions demand alterations in design, or in the details of design, so that the proper lubricant may be used in an efficient manner.

The interest and attention of scientists and engineers has been directed to the behavior of oil and oil films under various conditions.

EDITOR'S NOTE: The information on which this article was based was furnished by the Technical Department of the Vacuum Oil Co., New York, N. Y.

Recent papers and books upon the subject show the keen appreciation of the value of, and the necessity for, mechanical conditions that will promote the efficient use of lubricating oils. Widely theoretical as some of these have been they, nevertheless, have exerted an influence upon the practical application of oil.

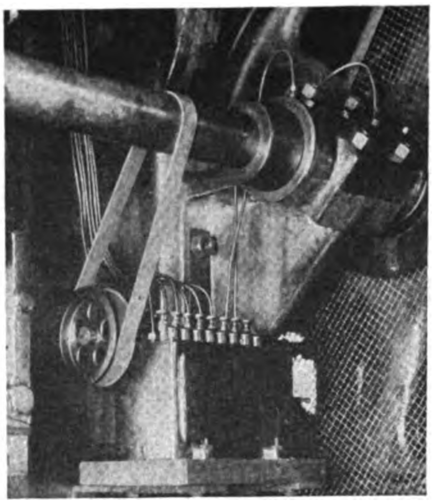
In the early days of machine design and operation, little thought was given to caring for the needs of the moving parts. It was recognized that some form of medium must be introduced between the frictional surfaces so that the parts could move one on another. The crude designs and slow speeds of operation did not make very serious demands upon the lubricant, and grease or tallow was commonly used.

Grease, although it performed its function in the older, cruder types of machine, did not perform its function with the efficiency of a fluid lubricant. Although metal-to-metal contact was avoided to a certain extent, the factor of efficiency of the lubricant itself had still to be considered, particularly as speeds were increased. Power consumption became a factor, as well as facility of oil application and freedom from wear.

It became apparent to engineers studying lubrication that fluid friction in an oil, especially in the lighter oils for bearing service, was considerably less than that of grease. Lubrication failures, due to the use of grease and unsuitable oils inefficiently applied, often made it impossible to keep the machines up to their normal speeds. Improvements in operation were obtained by better lubrication methods and by the employment of the most suitable oils. This improvement was evidenced both in terms of lower power consumption and reduced wear. Thus oils superseded greases as lubricants, bringing in their wake, changes in the design of bearings and lubricating appliances.

There has been a stepping up all along the line in matters pertaining to lubrication. Hand-oiled bearings are rapidly giving way to drop-feed cups, wick-feed cups and other semi-automatic appliances. Also, bearings formerly equipped with such cups and semi-automatic lubricating devices are being equipped with splash or circulation systems.

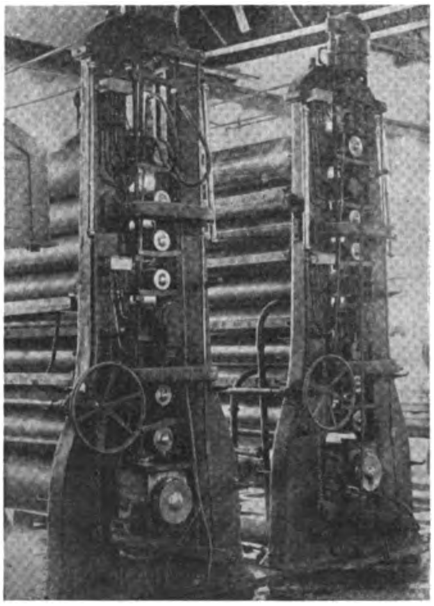
These advances in methods of application have been accompanied by a corresponding advance in the manufacture of lubricating oils. Even oils for lineshafting cannot be used broadly if the best results are to be obtained. The distinction in oils due to body, general characteristics, and methods of refining, make one oil more suitable for certain purposes than other oils.



The bearings of this punch press are lubricated by a mechanical force-feed lubricator.

Inasmuch as there is little wastage, high-grade oils may be used economically by the use of devices of this character, which feed the lubricant positively.

The theory of "floating" a shaft on an oil film, while not new, is basically the idea of the whole modern practice of lubrication. The trend of developments during the past few years has been to emphasize the need for oils that will cover each specific condition of frictional contact and provide that oil film in the most economical manner. Lubrication has become, instead of being an isolated factor in the maintenance and operation of a plant or mill, a factor affecting every branch of industry in terms of production. There has been a recognition on the part of manufacturers and designers of machinery that no machine can run efficiently or effectively and maintain its proper operating condition without due provision for the use and application of the proper lubricant.



This shows an application of the wick-feed principle to the bearings of a calender stack in a paper mill.

This general increase in the knowledge of the principles of correct lubrication, due to the publication of treatises by lubrication experts, engineers, and scientific writers, has been of invaluable assistance in the improvement of lubrication practices. The theory of lubrication is taught in colleges and universities of standing, where, only a few years ago, little or nothing was known of the subject. Today the technical graduate leaves school with at least a working knowledge of the basic principles of lubrication.

Lubrication practice has improved immeasurably. The idea that lubricating oils, no matter how high grade the product, are far cheaper than repair parts, renewals, and power costs, has taken root extensively, with the result that there is a demand on the part of the consumers for high-grade products, where only a few years ago it was impossible to interest the users of the same class of equipment in anything but the cheapest grade of oil. A number of "low-grade oil" users have come over into the class of "high-grade oil" users within the past two or three years, and others are on the way.

The human element, which formerly predominated in matters of lubrication, is gradually being eliminated. The uncertainty and the lack of care, the periodic application such as was inherent with hand-oiling methods, and the existence of isolated points of application, are today being supplanted in many important classes of machines by automatic devices which deliver the oil continuously and in positive, controlled quantities, thus providing constant and controlled application.

These systems gave rise to a new set of oils to meet the requirements of the new conditions and of new methods of treating the oil while in service. The circulation system, which was necessary to the operation of the steam turbine at high speeds, is fast finding favor in other indus-

tries, not only for bearings but for gears. Machine tools, paper machines, steel mill machinery, reduction gear sets, and so on, may be listed among the groups that have been converted to the use of circulating systems for lubrication. Splash lubrication has come into general use on several classes of machinery to which it is adapted. This has also created a demand for superior grades of oil.

Other modern systems of lubrication are advancing the cause of economical lubrication. Mechanical force feed lubrication forms a positive means of introducing high-grade lubricants in an economical way, as is necessary with the use of high-grade oils. The cost of the lubricator, which was a stumbling block to many users of machinery, has proven to be a small investment compared to the benefits derived from improved lubrication and the economical use of high-grade lubricants.

The modern tendency is to use automatic lubricating systems wherever possible and to demand the use of the highest grade lubricants obtainable in such systems.

The most pronounced advance in the science of lubrication has been the recognition on the part of manufacturers and users of mechanical equipment, of the fact that any improvement in the means of applying lubricants, or in the efficient distribution of the oil in the bearing or cylinder or between the gear teeth, or the more careful selection of the oil to insure the use of the most suitable lubricant for the conditions, will improve the running of the machine, prolong its period of usefulness, and ultimately result in economy. This is indeed no small step in assuring to the science of lubrication its proper place in the industrial world.

The actual performance of correct lubricants, when properly applied, and the tangible results obtained thereby have been instrumental in bringing about the change in attitude toward the lubrication problem. A few cases where the performance of lubricants has been recorded will serve to show the importance of improved lubrication and will demonstrate that a great economic gain is possible by the study and application of scientific methods to every phase of machine operation.

One of the economies of modern lubrication is obtained by long service of the lubricant. In systems where the oil is used over and over, it is important that the oil be of such a nature that it will withstand the high temperatures, continuous use, contamination from outside sources, and deterioration due to chemical action.

Circulation and splash systems, both of which use oil in quantities, cannot prove to be an economy, as far as oil consumption is concerned, unless oils that will give long service are used. Although there are many applications of these systems of lubrication, the steam turbine offers an excellent example of severe, continuous service. Many cases have been noted where excellent service has been rendered in such systems, as, for example, in the case of a 3,200-kw. steam turbine which ran for two years on a single charge of oil. This turbine was practically in continuous operation during the entire period. During that period 40 gal. of "make-up" oil were used or an average of 20 gal. per year. Subsequent to the removal of the oil from the system, its condition was considered to be sufficiently good to warrant its use about the plant for other less important lubrication work.

In any unit where a quantity of oil is required for each charge of oil, the probable length of the life of the lubricant must be carefully considered. Also, in small splash or circulating systems long life is a factor both from the standpoint of the cost of the oil, as well as from the cost of the labor involved in draining, cleaning and replacing the oil.

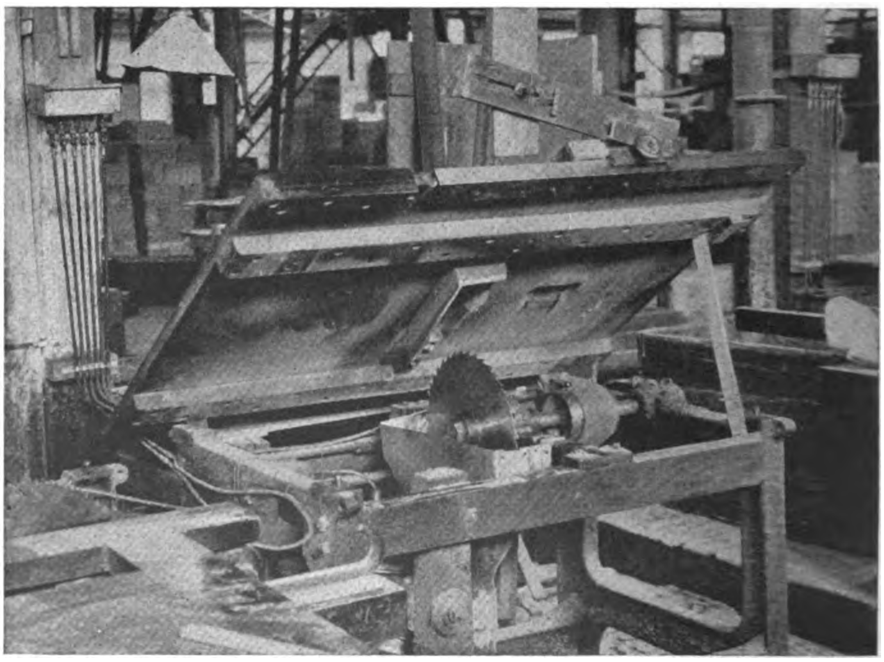
Oil consumption is another item of lubrication that is capable of reduction. In one case, by way of illustration, a band saw employed for cutting cork was using oil at the rate of 1 gal. a day, which apparently was not too much. However, the use of the right oil applied at a rate of feed that was sufficient to supply the requirements of the machine, reduced the oil consumption to 2 qt. per day, thus effecting a saving of 50 per cent of the original amount. Such savings effected on the machines throughout a whole plant have been made with the controlled application of oils of high lubricating value. When considered on a yearly basis in terms of dollars and cents, this saving considerably reduces the operating cost of the plant.

Another saving along the same line is to be found in the case of a group of 15, 1-ton electric mine locomotives. Each of these units was using 1 qt. of oil every five days. This was reduced to 1 pt. of oil each per five-day period.

The fact that these economies in the cost of the lubricant and other economies in the form of reduced repair costs can be made at the same time, deserves careful attention. A reduction in oil consumption, accompanied by increased cost of repairs and renewals of parts would be poor business. However, the reduction of oil consumption while mechanical

Here is a successful application of a wick-feed box with multiple feed to the bearings of a wood working machine.

The rate of feed of the lubricant is controlled in this case by varying the amount of wicking in the top of each feed pipe. With these boxes it is possible to stop the feed to all bearings by throwing a single lever.



conditions are maintained or improved, is to be desired at all times.

In one plant making a well-known product, the mill foreman estimates that there has been a reduction of 50 per cent in the number of bearing renewals during the 6-mo. period subsequent to the installation of improved lubrication. Simultaneously, there was a reduction in the cost of lubricants from $1,700 to $1,350 and a further reduction in the cost of labor for applying them. The savings given in this last example do not take into consideration the increased production due to the operation of the machines without shutdowns for repairs.

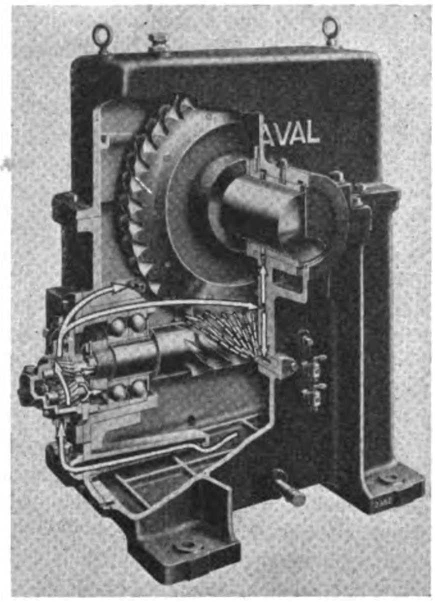
Another instance of a similar nature occurred in a woodworking plant operating eight stickers. Here an average of one sticker bearing had to be replaced every week at a cost of $15. Subsequent to an analysis of the conditions and the application of suitable oil, it was found that it was necessary to replace a bearing only every 3 mo. which effected an annual saving of $690. The superintendent is authority for the statement that hot bearings are unknown in his plant now.

Such figures taken from actual experiences in the industrial world must be accepted as the most convincing evidence of the efficacy of lubrication when applied according to the best practice. That proper industrial lubrication is a "tremendous trifle" is obvious from a consideration of the previous instances.

Power consumption, while not a salient factor in the operation of every machine, represents an item of expense to the plant or factory whether the power is generated in the plant from fuel of one kind or another, or whether it is power purchased in the form of steam or electricity.

Two causes of excessive power consumption are inadequate lubrication or the lack of effective lubrication. The first of these results from the failure or inability of the oil to supply and maintain a complete oil film. This results in friction of the metal surfaces, which in turn causes wear of the surfaces, as well as increased power consumption. Therefore, any improvement in the lubrication from the standpoint of reduction of wear is likely to result in a reduced power consumption.

The other cause of excessive power consumption is the result of using an oil which, although it may protect the surfaces from wear, is too heavy from the standpoint of "oil drag." Considerable power may be consumed in the work of overcoming friction in the oil itself. Correct lubrication provides for the prevention of metal-to-metal contact, and at the same time insures the least friction loss which would result from the use of an oil heavier than necessary. For example, in a paper mill a reduction in the cost of lubricating oils was accompanied by a reduction of 16⅔ per cent in power cost, in spite of an increase in production in the plant during the same period.



One type of positive pressure oiling system for a worm gear speed reducer.

The splash system, wherein the worm dips into the lubricant and the oil thrown off from the gear is allowed to find its way down the sides of the case to the bearings, is generally used on speed reducers of this type that are designed for ordinary operating conditions. However, in the case of large-capacity units, or where the speed is high, the splash system may not be satisfactory. The illustration shows the method used in the De Laval worm reduction gear to supply the bearings with oil under pressure. As will be seen, the oil is drawn through a strainer located some distance above the bottom of the oil reservoir, by a pump which delivers it through passages in the casing to spray nozzles located on both sides of the worm, and also to all bearings.

Direct power savings are most noticeable in the case of prime movers, such as steam engines. In the lubrication of cylinders, the piston sealing effect of the oil is to be obtained in addition to the factors affecting power economy just mentioned. A change of lubricating oil in one plant reduced the fuel oil consumption for power generation from 2,100 gal. per day to 1,700 gal. per day, thus showing that the theory of correct lubrication works out in practice in no unmistakable terms. The chief engineer of the mill in question confirms these figures.

Labor is a big item of expense in the operation of most industrial plants. Any saving in this respect is a clear profit. That lubrication, in the modern sense of the word, and lubricating devices which are designed to reduce the care and attention necessary with hand-oiled machinery have contributed to the reduction in the expense of plant and mill operation, is amply demonstrated by actual figures.

Savings in the cost of the application of oil to bearings are shown in the following example. A tool manufacturer applied inexpensive automatic devices to the overhead shaft bearings and found that one filling of these devices would last three weeks. However, the devices are filled every two weeks at a total cost for the year of about $37. Previously, the bearings were oiled by hand daily. This operation required 3 hr., at a cost of approximately $1.50 per day or a total cost of $9 per week. Calculating this on a yearly basis shows that it cost $450 to hand-oil the same bearings that are now being lubricated regularly and continuously at a cost of approximately $37 over the same period.

The application of the lubricant is not the only labor expense involved. Other labor savings, directly traceable to the scientific application of oil, are evident in other phases of plant operation. The following is an example of a saving in labor attributable to better lubrication, which resulted from the elimination of the necessity for cleaning compressor valves. The excellent condition of the valves is a direct result of the right use of a suitable lubricant. In the plant referred to, the valves in the cylinders of three gas compressors had to be cleaned monthly, representing an expense for labor of about $40 per cylinder. During the first 6 mo. after a better lubricant was adopted, the valves were cleaned only once, thereby effecting a saving of approximately $200 per cylinder, or $1,200 for the whole plant. The slight amount of deposit found on the valves at the end of six months was easily removed with kerosene, whereas with the oil previously in service, the hard carbon deposits caused considerable breakage of valves.

In another plant, a paper mill, the work of six men was required for one

day each week to clean the oil from floors and machines, due to the over-application of oil. With improved lubrication, six men spend one day every fourth week cleaning up oil. This represents a payroll saving of 18 man-days per month which amounts (in this particular mill) to $72 per month.

Labor savings may also be traced to other places in the plant or mill as a result of the care and attention to the selection of the right oils and their application by modern methods.

These instances of the bettered conditions that have resulted from improved lubrication amply bear out the statements made in the earlier part of this article. They offer a concrete reason why so much interest and enthusiasm have been aroused during the past few years in the study of lubrication problems and the development of lubricating oils of the right characteristics to meet the conditions of service encountered today.

When the user of oil is assured of long service of the oil he puts in his system, that is, economy by reason of the better lubricating value of the oil; when he is assured of reduced repair costs in terms of dollars and cents — something that actually shows on his books and about which there is no guesswork or theorizing; when he sees his cost of power consumption decrease or his bill for fuel reduced appreciably; when he finds that some of the men whom he had employed about the plant for the application of oil, or for cleaning his machinery or his floors about the machines, may be released to perform some really productive work about the plant, he is then convinced that modern lubrication is an accomplishment of real importance to the whole industrial field.

Care of Leather Belt Drives

(*Continued from page 468*)

leather belting that requires no more than one take-up and often runs 6 mo. or a year without moving the motor back more than 1 in. on the sliderails.

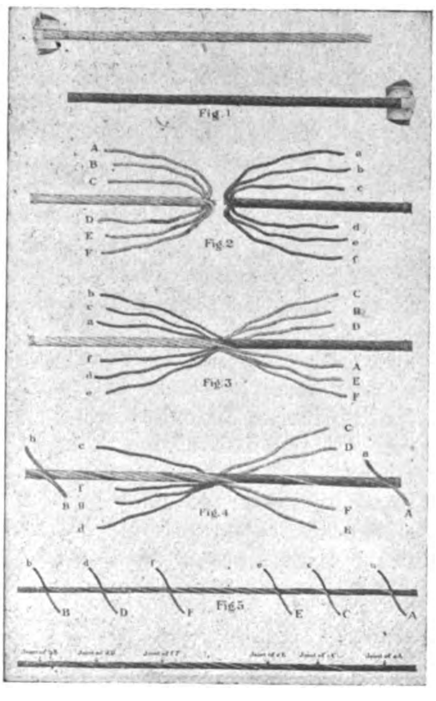
Methods of lubricating and dressing belting leather have also been greatly improved by the manufacturer, so that the best belts today last longer and have a higher leather fiber content. Every man who has anything to do with the maintenance of leather belts should have a set of simple rules on the care of leather belting in the shop. These are very interesting and are available in booklet form from the manufacturers of leather belting, for anyone who will ask for them.

The belt is but a small part of the cost of each production machine, but, like the arteries in the body, it is very important. A good leather belt, bought according to standard tests, will increase production and save trouble and money for the company. A leather belt should always be purchased on quality, because the quality leather belts are always the least expensive, so much so that no other kind should even be considered. The testimony of every practical shop man will bear out this contention.

In summarizing, some of the simple rules which should be followed by all power transmission men are given in the box on page 466. Operating executives who see to it that their belts are given the proper attention, will not only have a better operating plant, but will have a new and higher respect for reliable leather belting.

Recommended Method of Splicing Wire Rope

IN ORDER to prevent appreciable loss of strength at the splice in a wire rope, it is customary to make the length of the splice not less than is given in the accompanying table for ropes of different sizes.



Diameter of Rope	Length of Splice
1/2 in.	15 ft.
5/8 in.	20 ft.
3/4 in.	24 ft.
7/8 in.	28 ft.
1 in.	32 ft.
1 1/8 in.	36 ft.
1 1/4 in.	40 ft.
1 3/8 in.	45 ft.

The following method of splicing wire rope is recommended by the American Cable Co. In splicing the two ropes, fasten the ends so that they overlap, allowing for a splice of 15 to 45 ft. as indicated in the foregoing table. For purposes of explanation we will assume a 30-ft. splice. First wrap or tie the ends securely with iron wire 30 ft. from each end, then unlay all strands 15 ft. as shown in Fig. 2 of the accompanying plate, cutting away the hemp core to permit bringing the two unstranded ends together so that the strands will interlock as in Fig. 3.

Take strand *a* and unlay it until the wire binding is reached and in the open groove place strand *A*. Lay *A* in tightly as shown in Fig. 4, making the twist agree exactly with twist of the open groove. Proceed in this way until all except 2 ft. of *A* are laid in and then cut off *a* and *A*, leaving the ends about 2 ft. long. Now unlay strand *B* in the opposite direction and in its place put strand *b*, stopping the ends of the rope in position corresponding to *A*, Fig. 4.

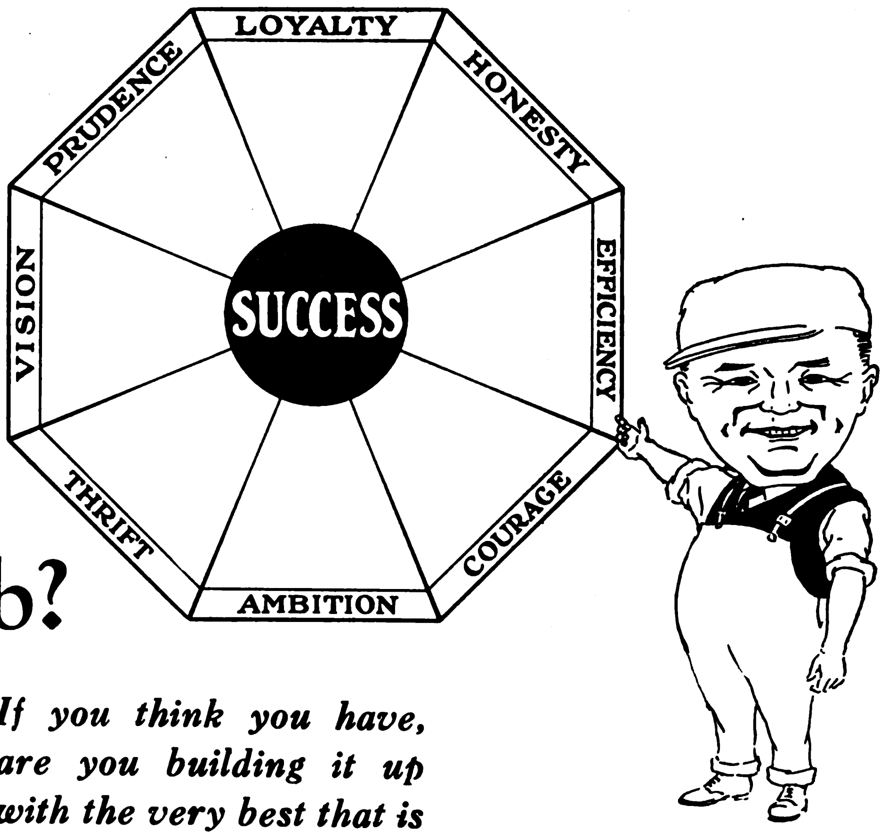
Subsequently *c* will be replaced by *C*, but this should be stopped 6 ft. short of the junction of *A* and *a*, as shown in Fig. 5. Similarly, *D* should be replaced by *d* and the end stopped 6 ft. short of strand *B* and *b*.

Proceed similarly with *E* and *e* also *F* and *f*, stopping the ends 6 ft. short of *C* and *c* and *D* and *d* respectively.

The rope will now present the appearance shown in Fig. 5 and the only remaining step is to tuck in the ends in such a way that the diameter of the rope will not be increased where the ends are tucked in. This is done by removing the hemp center and putting the ends of the strands in the place previously occupied by the core. To do this, it is first necessary to open or untwist strands *A* and *a* so that the hemp center can be seized with a pair of pliers and pulled out. Then a marline spike is inserted to keep the gap open. After starting the loose ends into the space left vacant by the hemp center rotate the marline spike to force strand into place.

These illustrations show the different steps in splicing a wire cable.

Have You A Good Job?



If you think you have, are you building it up with the very best that is in you?

NOT long ago when calling on the Chief Engineer of a large plant and waiting in his office while a factory signal gong was locating him for me, I chanced to see on the wall of his office a real message. This message is reproduced in its essential details in the accompanying diagram and has helped me to understand this fellow, whom I have come to know well and admire. There were no other hangings or decorations in that office and the above diagram took up a space about 3 ft. square. Under it appeared this comment:

"Have you a good job? Until you get a better position the one you hold is the best there is, and it deserves the best you can give it. Better workers always get better jobs."

This man employs many men and he is their boss in every sense. He exercises his authority not by force or fear, but by his own ability to do things and the way he goes at them. He does not stand on the sidelines and watch the game: he gets into it and while he is the leader, he knows how to place responsibility and build confidence in assistants that he can depend upon.

The above diagram tells a lot about this fellow, and by talking with him and his principal assistants you quickly get the impression that his is not a one-man job, but a job built by him around several men whose vision and ability have grown with the work and responsibilities that they have taken on as a group Moreover, when you talk with his men alone they do not give you the impression that they are the whole thing, but you are impressed with what they know about the work they have in hand—not just a part of it, but the many related details. When it comes to arriving at a decision, however, then it is that the leadership of the boss comes in, for in every case when I have been interested and present, these men bundle up their facts and figures, plenty of them and complete in all details, and consult with the boss. At these times he seldom has to request that missing data be secured, for it is all there and they need no assistance in gathering in the facts. What they want and what they get freely is help in analyzing the problem at hand and arriving at its best solution. As a result of this procedure there are few misfits in this plant, and every one seems to be proud of that fact.

And so from this plant and its operators we can draw the conclusion that success in work, or success in ambitions is the result of a definite plan, consistently pursued and carefully worked out. Back of and along with this success must be certain fundamentals which I think are well laid out in the above diagram with its eight elements making up the wheel of success. Whether by intention or not, you will note that on the top, bottom and two sides stand Loyalty, Ambition, Vision and Efficiency, tied together by Prudence, Honesty, Courage and Thrift, with all revolving around or contributing to SUCCESS.

The more you study this diagram and think about the way it is made up, the more interesting it becomes. Try it!

Practical Pete

INDUSTRIAL ENGINEER
Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories
G. A. VAN BRUNT, *Managing Editor*

One More Reason for Standardizing General-Purpose Motors

INDUSTRIAL ENGINEER has often commented on the necessity for motor standardization. The steel industry has realized it for some time and has taken steps towards obtaining standardization of mill-type motors, as was reported in the June and July issues. But this movement takes no cognizance of general-purpose motors.

A letter from one of our readers, who is Chief Electrician in one of the 25 plants operated by his company, states what may be an extreme case, but nevertheless one that is characteristic of many plants at the present time. He says:

> "In the plant at which I was formerly stationed, there are some 240 motors—*of which no two are alike*—manufactured by 17 different firms. The stock of repair parts is so large that it cannot easily be imagined. In the course of time we expect to work this number of motors down to those of three or four manufacturers, but for the present it is necessary to operate the 240 mismates."

The troubles of the Chief Electrician in such a plant can be readily imagined. The crime, however, must be laid at the door of the man who specified motors from 17 different manufacturers. Either he carried to extremes the desire to try something new, or was unduly influenced by the price offered by some manufacturer to introduce his motor. Until manufacturers are able to standardize their motors, it will be necessary for users to limit their motors to two or three, and preferably less, different makes.

The Best Time to Fight Fire Is Before It Starts

MOST of us would admit, if we were asked about it, that fire is an ever-present and apparently ever-growing menace, but in the rush of the days' work we are inclined to grow careless and overlook some of the precautions that are essential. There is, consequently, need of calling attention from time to time, to the importance of cleaning up our plants, inspecting firefighting equipment to make sure that it is in good condition, and so on.

Fire Prevention Week, Oct. 3-9, was inaugurated for this purpose, and it is safe to say that proper observance of it may be the means of saving millions of dollars worth of industrial property.

The best way to fight fire is not to let it get started; a plant may be doomed to destruction within a few minutes after a fire breaks out. Many fires start in accumulations of inflammable material, such as waste paper, shavings, dust, and the like. Oily rags are an especially dangerous fire hazard. Preventing the accumulation of such material is a matter of plant housekeeping that should receive careful and continuous attention.

If inspiration is needed, take it from Fire Prevention Week and inspect the electrical equipment and wiring, particularly extensions and temporary installations, to make sure that they are safe from the standpoint of fire hazard, as well as safety to the workmen. Carefully check the condition of all firefighting and protective equipment. Otherwise, injuries or deterioration that will make such equipment useless, may go unnoticed until an emergency arises; then it will be too late to make repairs.

Go over the plant from end to end, clean out all rubbish, and eliminate any potential or actual fire hazards that you find. After the plant has been put in good condition, from this standpoint, see that it is kept in this condition. Then you can feel that you have done your part in protecting your plant or your job, and in reducing our annual fire loss of more than one-half billion dollars.

Do You Know How Much Energy Is Wasted By Your Power Drive Equipment?

NOT long ago the management of a large industrial plant was faced with a serious power shortage at the height of the busy season. The factory power plant was in good condition, but it was overtaxed by the growing demand for power. Accordingly, after considerable investigation it was decided to install a new boiler, engine and generator, at an estimated cost of more than $25,000.

A new Chief Engineer took up his duties just before the order for this equipment was placed and two or three days' investigation convinced him that it was not needed. He found that power was being wasted everywhere, in a multitude of ways. After considerable discussion he received permission to make some changes he had proposed, and the order for the new boiler and other equipment was held up.

First, he installed anti-friction bearings on every lineshaft in the plant. Following this, a large number of countershafts were eliminated, some old equipment was discarded and new purchased, and other changes made that reduced the friction load to a fraction of its former value. Then direct wastage of electrical energy was attacked. Idle operation of motors and machines was strictly forbidden. Likewise, burning of lights when not needed was stopped. And so on through a long list of the various ways in which power may be wasted, in small amounts as well as large. As the result of these economies the power plant was able to carry its load without difficulty, and with no expenditure for new equipment.

There are plenty of industrial plants today in which

there are fine opportunities to save power and cut operating costs by the application of good sense and sound engineering, supplemented by the authority to purchase equipment that is modern, efficient and well suited to the service conditions. Frequently, these opportunities are entirely overlooked, unless some crisis makes decisive action imperative, as in the above case. However, if power is purchased, there is not likely to be a shortage of this to serve as the stimulus to investigation and constructive thinking on how operating and maintenance costs can be reduced and the operating efficiency of power drive equipment improved.

It is hoped that every industrial executive who is concerned with plant operation will find that stimulus in this issue of INDUSTRIAL ENGINEER. It has been planned for that purpose.

Don't Leave the Lighting System Out of Your Winter Preparations

THE winter months, with their short days and long periods of darkness necessitating artificial light, will soon be with us. Now is the time to put the lighting system in order for the early morning and late afternoon periods when it will be needed. In particular, maintenance attention at this time will prevent much trouble and expense later, when the weather makes it difficult to get at outdoor lights and lights in semi-closed buildings. Also, a survey of what lighting is required may prove of decided value.

Too much light is something that is practically never found in an industrial plant. A careful investigation will probably reveal many places where more illumination would increase production or cut the cost of operation. Possibly some extensions have been added to the plant during the summer months. Have the lighting requirements for these locations been given careful attention?

Replacements of lamps should be made before a lamp burns out from old age. Typical performance curves on commonly-used sizes of lamps show that after 500 hr. use, the lamps give only 90 per cent of the light output that they do when new. Likewise after 1,000 hr. use they deliver approximately 80 per cent of the light given when new, while after 2,000 hr. use, the light delivered is only 70 per cent of its original value. The useful life of a lamp is considered to be 1,000 hr., but under conditions more severe than the laboratory in which the foregoing figures were compiled, the useful life would be even less.

Only a few weeks ago the eighth reduction of Mazda lamp prices since 1920 was made. Prices of these lamps are now 44 per cent below the 1914 prices. This in itself is still another reason why lamps should be replaced oftener.

If cost of operation is one of your bugbears, an investigation and overhauling of your lighting system may easily show places for cost cutting.

Replace Obsolete Control Devices With Modern Equipment

THE use of electric drive in industry is now quite commonplace and is the initial step in operating efficiency. However, there are very few plants where increases in production, reduced costs, increased safety, or decreased maintenance expense cannot be effected by replacing obsolete control apparatus with modern control equipment that is specifically designed to meet certain operating conditions.

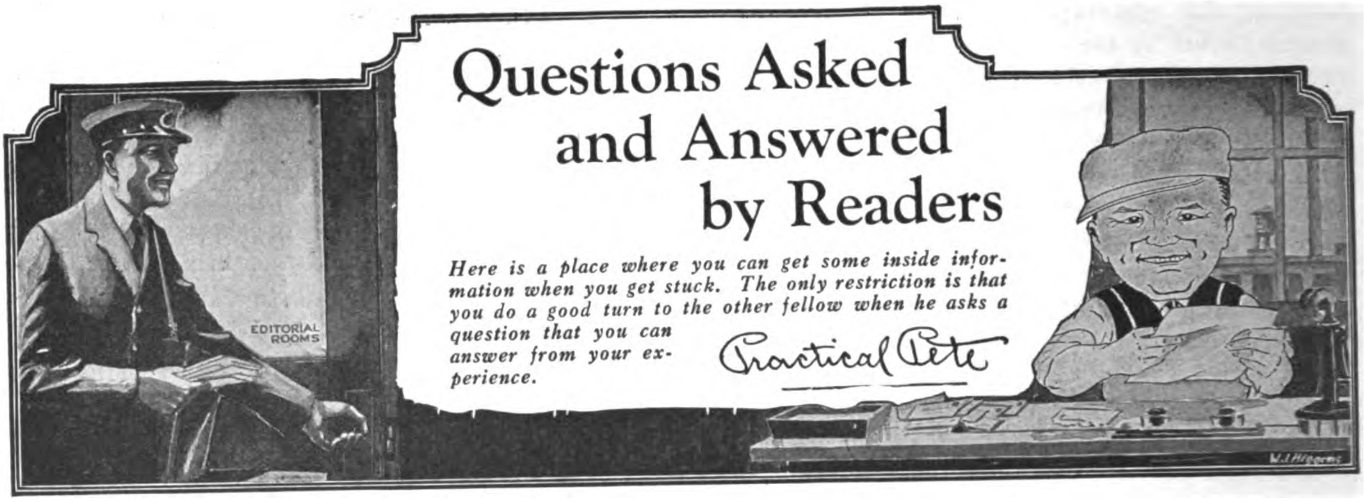
For instance, a 75-hp. motor used to tilt a Bessemer converter in a steel mill, was controlled by an old type of manually-operated controller. Considerable care was required of the operator, in gaging the limits of travel, and when a change of operators was made, some time would elapse before the new man became familiar enough with the method of handling the controller so as to tilt the converter in the shortest possible time without causing any spills.

After study of the problem by a control expert, an automatic controller was installed with limit switches at each end of the travel. The control is now operated by simply moving a small master switch handle from one position to another, whereupon the motor is automatically started, accelerated, and stopped at the proper position without any further effort on the part of the operator. The time saved, and the saving from spills formerly encountered, have paid the cost of the new controller in a few months.

In another case a winch operator and two men were required in a coke plant to operate a manually-controlled, motor-driven winch which was used for moving hopper bottom cars while they were being loaded with coke. Substitution of a car haul winch automatically controlled from a master switch at the coke screen operator's hand eliminated the winch operator and his two assistants and at the same time secured better loading of the cars because the screen operator could regulate the car movement to better advantage. The saving made by this installation paid its cost in less than a year.

A good example of the safety features of modern automatic control is the use of dynamic braking that can be applied in an emergency to prevent injury to workmen on candy pulling machines in candy factories, kneading machines in macaroni factories, and on rubber calenders in rubber mills. In case of trouble, any workman or person in the room can push any stop button and dynamic braking will bring the machines to a quick stop. This method of stopping machinery by merely pushing one of the conveniently located buttons has often prevented serious injury to workmen.

With high wages, and with investments in machinery as well as interest charges hardly declining, isn't it worth while to get a greater return per man or per machine? Modern electric control will help you in this regard. What others have done in the way of speeding up production and cutting operating costs you also can do.



Who Can Answer These?

Data for Building Auto-Transformer.—I wish to build an auto-transformer for use on 110-volt, 60-cycle current. This auto-transformer should have a capacity of 15 amp. and should have taps for voltages of 10, 20, 30, 40, 50, and 80 volts. I had planned to use a core made up of iron wire. Will this work satisfactorily? Can some readers give me the correct dimensions of the core that should be used, the size of wire, and the number of turns of wire that will be required. I shall appreciate your help.
Bayonne, N. J. E. J. M.

* * * *

Method of Ventilating Baking Oven—We are about to build an oven to be heated by electricity, which is to be used for baking coils and armatures. The oven is to be 9 ft. long, 6 ft. wide and 6 ft. high, and is to be placed out of doors. Can some reader tell me what is the proper way to provide ventilation for this oven? Any suggestions that readers can give me on this subject will be very much appreciated.
Fairmont, W. Va. R. M. F.

* * * *

Using Large Diameter Pulley on Motor.—Is it practicable to use a 20-in. pulley on a 25-hp., 750-r.p.m. motor? This would result in a peripheral speed of the pulley of 3,926 ft. per min. Would this be good practice? What objections would there be to using this size of pulley on the above motor in view of the fact that the motor manufacturer does not recommend a pulley of this diameter? Can some reader tell me what types of pulleys I could use or could not use in this case?
Toledo, Ohio. F. H.

* * * *

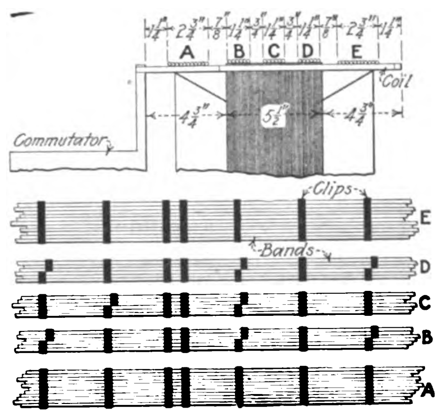
Cause of Fuses Blowing on Transformers.—During a recent violent lightning storm, the fuses were blown on one of our 10-kva., 2,300/220-volt, single-phase transformers. This transformer supplies a small, lighting distribution system. The transformer is protected by a pole-type lightning arrester. After the storm was over the fuses were replaced and the transformer operated satisfactorily. I shall appreciate any information that readers can give me on what caused these fuses to blow. I will be very much indebted to any reader who will advise me on this subject.
Wichita, Kan. Z. F. D.

* * * *

Trouble with Rewound Armature—I rewound a 5-hp., Crocker-Wheeler, armature which had 43 slots, and 129 commutator bars, each coil having 4 turns of 3 No. 14 d.c.c. magnet wires wound in parallel. The coil pitch was 1-and-10 and the lead pitch was 1-and-65. The armature tested clear of grounds, shorts, etc., but a bar-to-bar test with a millivoltmeter showed the following variations in readings: normal—high—low—high—low—normal—high—etc. I spanned about 12 bars in making this test. When assembled in its frame, the armature would seem to lock and would turn in jumps. The top leads were raised and tested for shorts, but everything tested clear. It was tried again with no better results. A duplicate of this armature was put in the same frame and it ran perfectly. The defective armature was then stripped and was found to be wound correctly and each coil was examined for the correct number of turns and cross-section but the coils were found to be O. K. Can some one tell me what the trouble was?
Iola, Kans. G. E. G.

* * * *

What Causes Armature to Throw Core Bands?—We are having trouble with the bands on an armature of a 75-kw., 2,400-r.p.m., 230-volt, 200-amp., four-pole, compound-wound turbo-generator. On account of a breakdown the coils were removed from the core, reinsulated, replaced, and connected as before. The winding was then tested with a growler and also a millivolt drop test was made. Next the five steel bands were installed as shown in the diagram. Each band is separate from the others and is



thoroughly soldered, with sheet copper reinforcing clips placed at six equi-distant points around the core, except at the start and finish of the band, at which point two copper clips were placed close together. After fitting the bands and again testing the winding, the armature was replaced and brought up to speed with the field circuit open. The field circuit was then closed and when the generator voltage rose to approximately 100 volts (less than half rated voltage), the bands became so hot that the solder loosened and the bands were thrown off. The airgap was ample, so that the bands were not striking the pole pieces. Furthermore, there was absolutely no indication of heating or other trouble in the winding itself. Will some reader please tell me what causes this armature to throw its bands? Is the trouble caused by having more than four equally spaced sets of copper clips around the periphery or by having two clips together, or both? Any information that readers can give me as to what is causing my trouble will be greatly appreciated.
Richmond, Va. W. H. E.

Answers Received To Questions Asked

Use of Non-Metallic Gears—I wish that our readers would give me their experience with the so-called non-metallic gears. We have several gear drives which wear rapidly, due to irregular loading, and soon become noisy. If I should use non-metallic gears would I have to use pinions with wider faces, and also have to replace the present gears with others having wider faces? If so, approximately how much wider would the faces have to be?
Des Moines, Iowa. J. F. K.

I would recommend that J. F. K. use a rawhide drive pinion of the same dimensions as the original one. It would seem to me that the gears which J. F. K. used were not lined up properly; otherwise, they would not wear out so rapidly. I believe that he will find the rawhide pinions to be very quiet in operation. Only one of the gears that mesh together needs to be rawhide.

The inherent resilience of rawhide enables this gear material to absorb the shock of tooth impacts and is responsible for the comparative absence of wear, and for quiet operation.

Chief City Electrician, H. J. ACHEE.
Woodward, Okla.

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As J.F.K. undoubtedly knows the speed of a set of gears has a great deal to do with the amount of noise that they make in operation. The depth of mesh also influences noise. For quiet operation, gears should be mounted so that there is very little backlash. When installing gears some millwrights recommend using a piece of ordinary writing paper for ascertaining that the mating gears are at the proper centers and do not bind nor ride too loosely. The gears should be mounted so that the paper may be run through without being torn or deeply indented, when the gears are revolved by hand. The size of the gear is another factor which must be taken into consideration with the speed if the drive is not to be unreasonably noisy.

I believe that rawhide pinions could be used with the present gears, provided the pressure per inch of face of the pinion does not exceed 250 lb. If these pinions have bronze flanges the pressure may be safely increased 25 per cent. GRADY H. EMERSON.
Birmingham, Ala.

In reply to J.F.K.'s question, non-metallic gears made from Bakelite Micarta D are generally considered equally as strong as cast-iron cut gears. Micarta gears may be substituted for steel, cast-iron, or bronze cut gears, having the same dimensions as the metal gears.

In some cases, non-metallic gears have not given satisfactory operation from the viewpoint of noise and economy. Investigation has usually revealed that this is due to some of the following causes: Misalignment, improper or insufficient lubrication, and wrong design. Micarta gears should be lubricated with a light grease or heavy oil; they should operate with metallic cut gears, and have a shaft bearing in the bore of at least one-fourth of the pitch diameter of the gears.

Generally, no metal endplates or shrouds are required, but in special cases where some noise may be sacrificed for additional strength, metal shrouds are used. In such cases, the shrouds are included in the working face of the pinion meshing with the metal gear. The writer has used pinions of this construction for additional strength where certain limitations prevented any increase in the width of the face. These pinions compared favorably with all-metal pinions in operation and life. E. H. LAABS.

Engineering Dept.,
The Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

* * * *

I presume that J.F.K. in his inquiry on the use of non-metallic gears, means the newer Fabroil or Micarta gears. We have used a number of these, especially for motor pinions, with very satisfactory results. In accordance with the makers' recommendations, we designed these gears by using the Lewis formula constants for cast iron and making the face about four times the circular pitch, as is usual for cut gears and, possibly, using a slightly coarser pitch than is customary with steel motor pinions. We are operating these gears loaded well up to their rated capacity and they have not shown any signs of wear or deformation. Because of these favorable results, we are inclined to believe that the data furnished by the manufacturers for the design is correct.

Bulletins on these gear materials, which contain much valuable information on the design of such gears and also include tables of desirable pitches and horsepowers transmitted, for simplifying the work of calculation, are furnished by the General Electric Co., Schenectady, N. Y., and the Westinghouse Electric & Manufacturing Co., Pittsburgh, Pa., the manufacturers of the two materials mentioned.

Our experience with rawhide and vulcanized fiber gears has been that they are, as given in the reference books, considerably weaker than cast iron so that per horsepower transmitted, the Fabroil or Micarta gear will make a cheaper drive, because both the silent pinion and the accompanying gear can be smaller. H. D. FISHER.

Plant Engineer,
New Haven Pulp & Board Co.,
New Haven, Conn.

Unfortunately, the information given by J.F.K. is not sufficient to make any definite recommendation as to the use of other materials and gear tooth widths. If the horsepower transmitted, the diameter and speed of the pinions, and whether they were made of cast iron or steel were known, some direct information could then be given in regard to the possibility of substituting some of the various types of non-metallic gears for the metal gears now used.

Up to the last decade, when the research departments of two big electrical companies developed a gear material from cotton sheets that were treated and compressed under enormous pressure, the chief non-metallic gear material was rawhide, a material that has served acceptably in drives ranging from small machinery to street car motors, pumps, and so on. Data on these new non-metallic gears (sold under trade names) may be obtained from their makers, but it should be remembered that an arbitrary substitution is not a guarantee of freedom from the present troubles.

These troubles go back to gear application design. It is well known that a gear may not wear well even though its individual teeth are strong enough to carry the load placed upon them. The remedy in such a case is to use wider faces. An old rule-of-thumb check on gear teeth has been to make the width of the tooth, in inches, at least 4½ times the number of horsepower transmitted divided by the pitch diameter of the gear in inches. The tendency toward high motor speeds has made it necessary to use better materials because cast-iron pinions, even though they had been designed according to this check, which was for ordinary machinery, would not stand up at the high speeds. As a result, pinions made of untreated and case-hardened steel and non-metallic compositions and materials of various kinds have been introduced to carry the increasing loads without increasing the width to undue sizes. In the street car field, and in some industrial work, hardened tool-steel pinions have given double the life of the soft steel ones so long in vogue.

J.F.K. says the pinions "become" noisy which implies that they were quiet at the start. It is evident that the load is too great and the speed too high for the width of face. At high peripheral speeds, 1,700 f.p.m. and over, unhardened metal pinions wear rapidly, due to the shock of contact and all gear formulas take this into consideration. It is at such velocities, and beyond, that the rawhide gear found favor because it cushioned the shock and was less noisy; it has been customary when using the best quality of rawhide to disregard peripheral speed altogether in designing gears.

According to the Lewis formula for gear teeth, rawhide teeth should have 1½ times the width of cast-iron teeth and 3 times the width of teeth made from 0.30 per cent carbon steel, if each is to transmit the same power.

J.F.K. would be no better off if he used non-metallic pinions unless he changed to new gears also, because the load-carrying area of the pinions is limited by the width of the gears. Also, it is very likely that the gears have worn so that they will continue to cut pinions as fast as new ones are installed. Good cut teeth roll, properly meshed, upon one another, but as soon as they wear out of shape the points in contact slide on each other and the resultant friction constantly wears off particles of metal.

J.F.K.'s troubles, however, may not be entirely due to too narrow faces. In many cases, the motors and the shafts they drive are not lined up parallel in both horizontal and vertical planes. This results in a condition which will start tooth wear the moment the switch is closed.

Where a motor is insecurely mounted or supported, or the driven shaft is loose in its bearings, misalignment and the same wearing conditions will result. When two gears do not line up the contact is at one end only, even if the gear and pinion are several inches wide and the amount of contact cannot be increased until that end has worn down. The wear, however, does not follow the theoretical shape of correct teeth, with the result that there is constant friction and noise throughout the shortened life of the gear and the pinion that meshes into it.

There is but one correct meshing position for a pinion in its gear. Owing to the difficulty of lining up motors, the best check is to use slips of paper or thin metal between the teeth before running the drive at all. These slips have to be rolled in place by turning the motor over by hand. They should "pull" the same in four positions; that is, at the top and bottom of a given tooth, at both ends.

In irregular loading J.F.K. has hit upon one of the most common troubles in the realm of transmission but withal one which is often given the least study. Irregular loading is often the cause of a noisy drive; to overcome this herringbone gears are being substituted in many cases. These gears, from the nature of their tooth angle, run quieter because backlash is better taken up than with ordinary spur gears. With intermittent loads, much of the noise is due to the rebound and does not result from contact between oncoming teeth.

The writer had a case of a motor drive on a metal planer that could not be silenced by gears, but was effectively silenced by use of a Morse chain and a compensating driven sprocket. On this installation a 6-ton table load, together with four large pulleys traveling at about 5,000 f.p.m., had to be reversed several times a minute. We had no trouble with gear tooth wear; however, the noise was so bad that the planer had to be stopped in order to use the telephone in a booth in the office about 100 ft. away. Even though we installed new pinions and new gears, then non-metallic pinions and new bearings all around, none of them had any effect upon the noise. However, the chain drive was so quiet that a whispered conversation could be carried on alongside the machine itself.

DONALD A. HAMPSON.

Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Paralleling Open-Delta-Connected Transformer Bank With Closed-Delta Bank.—I would like to obtain the experience of some of our readers in regard to parallel operation of an open-delta-connected bank of transformers with one or more closed-delta-connected banks of transformers. Under what conditions is such operation possible? How does the load divide between the several banks of transformers? How is the capacity affected of both the open-delta bank as well as the closed-delta bank? If we have two banks of closed-delta-connected transformers operating in parallel on both the high- and low-tension sides, will these two banks of transformers continue to operate satisfactorily and divide their load in accordance with their capacity, if one transformer is cut out of one bank so as to make an open delta connection? In this particular case, all of the transformers are of the same size, voltage, ratio, reactance, and were made by the same manufacturer.
Wilmington, Del. H. E. H.

In answer to H. E. H's inquiry I would say that from actual experience I have found the operation of transformers connected in this manner to be satisfactory.

In his book, "Transformer Practice," Taylor says that the removal of one transformer of a closed-delta group results in a very slight unbalancing, due to the fact that the impedance in the middle main being the algebraic sum of the impedances of the two outside mains, the resulting capacity is $1 \div \sqrt{3}$ or 58 per cent of the original capacity.

I know of a bank of three 500-kva. 25,000/440-volt transformers that is paralleled on both primary and secondary sides with a bank of two 200-kva. transformers which are connected open delta.

These banks supply power to four rotary converters and the load is divided in accordance with the capacities of the transformer banks.

Chief Engineer, PHILIP N. EMIGH.
The Mountain Water Supply Co.,
Indian Creek, Pa.

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The writer has operated transformer banks in the manner indicated on a number of occasions without any apparent serious results. In one particular case two 450-kva. banks, each made up of three 150-kva. units, but with one bank having one transformer cut out, were so operated for more than a month. Tests on the division of load between banks, made by putting a portable split-core transformer over each transformer lead, did not show any values exceeding the normal rating of the transformers. Theoretically, there might be some objections to this practice from the standpoints of regulation and voltage unbalancing between lines but, practically, the operation can be carried out. Naturally the capacity of the open-delta-connected bank will be reduced in proportion to the total capacity. It is recommended that tests be made in each instance when such operation becomes necessary.

C. OTTO VON DANNENBERG.
General Engineering & Management Corp.,
New York, N. Y.

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In reply to H. E. H., I would say that transformer banks can be operated in parallel if the following conditions are fulfilled:

(1) The ratio of transformation on all the banks operated in parallel must be the same. This means that the proper taps must be connected to the transformer terminals inside the transformer case.

(2) Units of the same capacity must have the same characteristics. This means that the reactance and resistance drops must be approximately the same.

(3) The polarity of the banks must be the same. Units of different polarity must be connected so as to obtain equivalent polarity.

(4) Phase rotation must be the same. A motor connected to the corresponding leads of all the banks must rotate in the same direction.

Transformer banks connected in open delta and operating in parallel with transformer banks connected in closed delta will divide the load in the ratio of 1.73 to 3. This means that with a total load of 100 kva. on two banks operating in parallel, one connected in open delta and the other in delta the proportion of the load carried by the closed-delta bank will be $(3 \times 100 \div 4.73 = 63.5$ kva. or 63.5 per cent of the total load and the load carried by the open-delta bank will be $(1.73 \times 100) \div 4.73 = 36.5$ kva. or 36.5 per cent of the total. A. NOEPPEL.
Chicago, Ill.

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Proper Foundation for Alternator.—(1) We are going to install a 133-kva., belt-driven alternator in the near future, and I should like to know how to make a suitable foundation for it. We are thinking of using a wooden framework. Is this alternator too large for such a foundation? I should like to know what type of foundation readers would recommend for this alternator, and also how the foundation should be made. (2) When the distance between pulley centers of the alternator and engine is long should the alternator foundation be heavier than when the machines are close together? How should the alternator be fastened to the timbers or other types of foundations that are recommended? I shall greatly appreciate any information that readers can give.
New Orleans, La. O. C. H.

Referring to O.C.H.'s inquiry regarding the foundation for a 133-kva., belt-driven alternator, I would say that the data furnished are rather indefinite as to the speed, pulley size and location, although some general information may be of assistance.

Unless local conditions make concrete or brick foundations impractical, I would not recommend a wood foundation as it is hard to get a good level bearing without the use of loose wedges. The softness and give in wood, together with a continued drying process, make it difficult to keep the machinery tight on the foundation and thus prevent vibration. Most of the motors up to 125 hp. that we have mounted on wooden foundations have been installed only for temporary service. As the wood shrinks and wears down, it will be necessary to tighten the foundation bolts periodically, in order to prevent the machines from vibrating. A belted machine should be installed on a sliding base so that the belt may be conveniently tightened, when necessary.

If the foundation is to rest on earth, I would recommend a concrete foundation which is about 1 ft. larger than the base of the machine. The base of the foundation should be set into the earth about 3 ft., or if there has been a recent fill dig down to solid earth. The top of the foundation should be built about 1 ft. above the floor level in order to keep the machine up out of the dirt and wet.

The lower end of the foundation bolts should not only have washers but should extend to within 6 in. of the bottom end of the foundation. The upper end of the bolts should extend through a pipe sleeve that is about 1 ft. long and 2 in. larger in diameter than the bolts. After pouring the foundation, the sliding base and machine should be set in the operating position and leveled high enough with iron wedges so that there will be plenty of clearance for about 1 in. of grouting. After lining up the machine, the base should be grouted in, being careful to fill in around the foundation bolts, in order to keep the base from shifting sideways.

It does not take an enormous foundation to withstand the belt pull of a motor or generator, but it is important to have the machine bolted down securely so as to prevent vibration.

Due to the fact that the arc of contact between the pulley and the belt is greater with a long belt than with a short one, it is likely that the total belt pull is slightly less with a long belt. Generally the difference in belt pull is not great enough to materially alter the size of motor foundation.

In fastening the alternator to the foundation, as has been described above, a standard sliding base as furnished by the maker should be used. Whether the foundation is of wood or concrete, through-bolts should be used in preference to lagscrews. In the event that a wooden foundation is used, through-bolts should be employed so that the foundation can be tightened up when necessary.

Much trouble with motors and generators can be eliminated, if a little more care is exercised when the machines are installed. H. D. FISHER.
Plant Engineer,
New Haven Pulp & Board Co.,
New Haven, Conn.

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Heating of Commutator on Rewound Repulsion-Induction Motor.—I recently rewound a G. E. single-phase ¼-hp. four-pole type RI 110-volt repulsion-induction motor and am having trouble with it on account of heating. The commutator seems to heat first and in about two hours the motor gets so hot that you cannot put your hand on it, and it keeps on getting hotter. It does this when running idle. I have tested the commutator, armature, fields, and bearings and they seem to be O. K. The armature is well balanced. I used No. 16 d.c.c. wire in the rotor and main field and No. 18 in the compensating field. I shall appreciate any information regarding the cause and remedy of this condition.

In the September issue an answer to R. S. states that the trouble on a G. E. type RI single-phase motor is due to the short-circuiting device. I have had considerable experience with type RI motors, so wish to say that this has no short-circuiting device. Two sets of brushes are placed on the commutator, at opposite sides. One set is connected by a jumper, while the other set leads to the compensating field.

This set is, in all probability, the cause of the trouble in the motor. If R. S. will change these back, that is

reverse the brush connections to the compensating field and then adjust the brush setting to the best running position, his troubles will probably be over. This is a common mistake on these motors. If an ammeter is available, place it in the line and determine the load on the motor. Then reverse the compensator field and again read the ammeter. The connection giving the lower reading on the ammeter will be the correct one.

Buffalo, N. Y. WALTER M. RENNICK.

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Trouble from Static on Belt-Driven Machines.—We have about 200 sewing machines all of which are belt driven. The girls who run these machines complain that they frequently get shocks from them. I believe that this is due to static from the leather belts which drive the sewing machines. I shall appreciate it very much if some reader can tell me how to prevent this trouble. I have grounded the sewing machines but the trouble still continues. To what should I ground the machines so as to obtain the best results? How should the ground be made? I might say that the sewing machines are placed on wood floors in a room that is quite dry and warm. Would the use of rubber belts correct the trouble I am encountering? I should like to learn the experience of other readers on this subject.

York, Pa. P. C.

Answering the question by P.C., we remedied a similar case of trouble in the following manner. Upon investigation we found that the static did not come from the individual machine belts but came from a larger belt driving the countershaft. As a remedy we simply attached a piece of No. 14 wire to the ceiling directly over this belt, so that a nut which was attached to one end of the wire hung within an inch of the belt. The other end of the wire was attached to a sprinkler pipe for a ground. This arrangement proved effective and inexpensive.

Electrical Dept., A. C. BARKER.
W. S. Libby Co.,
Lewiston, Me.

* * * *

My experience some years ago, before the guarding of belts was subject to state regulation as it is now, with a battery of belted Bliss presses knocking out heads for condensed milk cans, may be of assistance to P.C. The girl operators complained about the "electricity" in the belts and how it attracted their hair, particularly as they passed along the aisle near the belts. Almost any time, it would be possible to place a finger near one of the belts and see a ½-in. spark jump between the finger and the belt.

To remedy this condition we attached strips of copper to the frames of the presses, but insulated from them, and carried a wire from these strips to the steam pipes along the wall back of the machines. Each machine had its strip and ground wire. There were no more complaints after that.

Another advantage which we found resulted was the reduction in the loss from burned-out lamps in the drop lights for each machine. These lamps were close to the belts and in some way the static in the latter had a bad effect on the filaments (drew them to one side, we thought) and they would burn out in about a week. After the grounds were put on there was no more trouble with these lamps than with any other lights in the plant.

With the sewing machines in question, I believe that P.C. should ground the static before it gets to the machines. Presumably, this could be done by a grounded "busbar" running along under the bench and near the belts, or close enough to solder fingers to it, which would come near the belts, and in this way eliminate the static trouble.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

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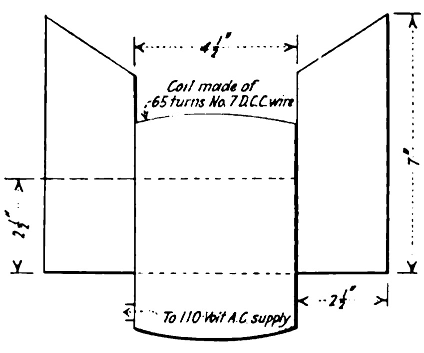
Demagnetizing a Lathe.—I have a 24-in. by 10-in. selective head lathe, which is magnetized; at least, when any work is done on the lathe, the chips cause us trouble by sticking to the lathe tool and surrounding lathe parts. It is my opinion that the spindle of the lathe is magnetized. I shall greatly appreciate it if readers will tell me how to demagnetize this lathe. If it is necessary to use a demagnetizing coil, how big should the coil be, how many turns and what size of wire should be used? Also, how many amperes should flow through the coil? Is there any way that I can demagnetize this lathe without using a demagnetizing coil?

Beaumont, Tex. O. C. B.

In answer to O.C.B.'s question I would say that this trouble may be easily overcome by placing the magnetized parts in a magnetic field that is subjected to frequent reversals. This can be obtained by placing the parts on a growler and then slowly moving the parts away from the growler while the current is on.



Data for making growler that may be used to demagnetize metallic parts of machines.

The accompanying sketch shows how I made a growler which may be used to demagnetize small machine parts. The core is made up from laminations of sheet iron of the shape shown in the sketch. Enough laminations are used so as to make a thickness of 2½ in. Sixty-five turns of No. 7 d.c.c. wire are wound on the center of the core. This is sufficient for operation from a 110-volt, alternating-current, power supply. For operation on 220 volts, use double the number of turns in winding the coil of the growler.

When demagnetizing parts, be sure to pull the parts away from the growler while the alternating current is still on. Turning the current off before the parts are pulled away has a tendency to magnetize them.

Chief Electrician, O. C. UMBERGER.
Premier Coal Co.,
Middleboro, Ky.

Although not so stated by O.C.B. the lathe which he mentioned as being magnetized, may be motor driven. The motor mounting, in that case, may be of the kind that has the motor fastened to the top of the head casting or to a bracket that is integral with some structural part of the lathe. Such being the case, it would be possible for the motor to be defective or to have been damaged to the extent of a ground or leakage of sufficient current to turn some part of the structure into a weak electro-magnet and this would, of course, cause tools and chips to stick to the various parts of the machine and cause considerable inconvenience.

The fact that O.C.B. states that he thinks the spindle is magnetized leads me to believe that the lathe may have been used somewhere previously with a magnetic chuck attached to the spindle for some special manufacturing. These chucks operate on 110- or 220-volt circuits and some of them carry 5 to 10 amp., which is sufficient current to magnetize the machine (lathe) particularly if there happened to be a short. If this condition had existed for a long time, the residual magnetism in the lathe's mass would be of sufficient amount to cause inconvenience for a considerable period.

It is hardly conceivable that the lathe would remain strongly magnetized unless there were some undiscovered source of magnetism operating while it is in use. Ordinarily, it would be much harder to *keep* a lathe (or almost any other part) magnetized than to keep it demagnetized. A careful investigation of all wiring near the machine and a test for grounds will probably reveal the real cause of the trouble. To a slight degree, a high-speed driving belt might be a contributing cause. If such is the case, metal combs located near the belt and attached to a wire grounded to a water pipe might help O.C.B. out of his trouble.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

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Where Should I Use This Kind of Wire?—Most manufacturers of wire for use in house wiring and in industrial plants make three kinds of wire: a Code wire, an intermediate grade and a 30 per cent rubber compound grade. I should like to learn from other readers whether they use all three grades around their plants and if so, the basis on which they decide the grade that shall be used for a certain application. Do you find any of these grades unsuited for industrial plant use? I shall appreciate any information that you can give me regarding the proper application of these three grades of wire.

Newark, N. J. B.S.

Referring to the question by B. S., code wire of the proper voltage should be used for all industrial power wiring. For lighting, open wiring in residences, signal and low-voltage work, the intermediate grade may be used, although it is not good practice if the wires are run in conduit. The 30 per cent rubber compound grade may be used on bell and low-voltage (50 volts and under) signal work and for open wiring on low-voltage lighting in dry locations. H. E. STAFFORD.

Electrical Engineer,
Provincial Paper Mills, Ltd.,
Port Arthur, Ont., Canada.

Electrical Service

around the works

For this section short articles describing ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing, and emergency or special installations.

Unusual Method of Fishing Through Conduit By Using Conveyor Wire

THE use of a so-called conveyor wire for fishing through a new type of metal molding used for surface wiring solved a difficult problem recently. This molding has an oval cross-section so that the wires lie in a row parallel to each other. The size used on this job will hold only two wires, and had many sharp bends in it so as to follow the surface against which it was laid.

Ordinary spring-steel, fish wire would not do for this job for it was too stiff to go around more than one or two bends. The conveyor wire while being sufficiently stiff to enable it to be pushed through the conduit, was nevertheless flexible enough to go around as many as four 90-deg. bends at one fishing.

This conveyor wire is made by winding steel wire in the shape of a spiral spring, and is about ⅛ in. over-all diameter. It is quite similar to the spring wire belts used on some fractional-horsepower drives, and is widely used in newspaper plants as a belt conveyor for carrying the printed papers from the presses to the mailing department. It is from this use that it gets its name of conveyor wire.

Seeing this conveyor wire used for fishing through the flat metal molding mentioned above, suggested that it could be used to advantage for fishing through standard, rigid conduit. It will readily go through the smaller sizes of conduit and will go round sharp beds with ease. It is more easily carried around by the workmen as it can be rolled up into a small roll without danger of kinking. This is more than can be said of regular fish wire.

New York, N. Y. A. J. W.

Record Cards for Listing Power Drive Data

THE need of keeping a record of motors and other power drive equipment is well recognized, but the means of doing so are not standardized and in many cases the methods used tabulate incomplete data which results in the files being much less valuable than they should be.

The card shown in the accompanying illustration has been used with great success in our plant. The outstanding feature is the completeness of the record of all spare part information regarding the drive.

On the top line of the card are recorded the name of the drive and the department in which it is located. Following this is a place for the complete nameplate data of the motor. After this, spaces are provided for recording the rewinding data for the armature, stator, and rotor as well as the data for making up or reordering slip-rings, commutators, field coils, brushes, and brush-holders for the particular motor in question. Note that in each case spaces are provided for each essential part of the description required to make or order the desired part.

Following the motor data, spaces are provided for recording the nameplate data of the control used with the motor. There are also spaces for recording all information necessary for reordering controllers, resistance, master switch and brake parts.

The bottom part of the card is devoted to miscellaneous parts of the drive such as the pinion, pulley, bearings, couplings, brake wheels, and the like.

On the back of the card is a place for recording the loads as tested at various times. At the top is a place for indicating the sizes of instruments required, thereby saving time whenever a test is to be run to check the loading of the motor.

Chief Electrician, J. F. MURRAY.
Follansbee Bros. Co.,
Toronto, Ohio.

Correction in "Determining Power Factor with Watt-Hour Meters"

A TYPOGRAPHICAL error appeared in the article by C. Otto von Dannenberg under this head on page 431 of the September issue of INDUSTRIAL ENGINEER. A formula for power factor was given as follows: Power factor in per cent $= 100 \times \frac{1}{2} \times \sqrt{(1 + X)^2} \div (1 + X^2)$.

This formula should have read, power factor $= 100 \times \frac{1}{2} \sqrt{[(1 + X)^2 \div (1 + X^2)]}$.—EDITORS.

Here is a motor record card that gives a complete record of the motor and other parts of a power drive.

No. 70

MOTOR DATA

DRIVE DEPARTMENT
MAKE TYPE FORM H. P. VOLTS AMPS PHASE CYCLES R. P. M. A C OR D C.
WOUND DUTY SEC. AMPS SEC. VOLTS FLD. SER. NO. ARM. SER. NO.
ARMATURE OR STATOR DATA: NO. COILS TURNS SIZE WIRE LEADS THROW WOUND
DWG. NO. STYLE NO.
ROTOR DATA: NO. COILS TURNS SIZE WIRE LEADS THROW WOUND STYLE NO.
SLIP RINGS: MAKE PATT DWG. NO. STYLE NO
COMMUTATOR DATA: NO BARS MAKE THROW STYLE NO DWG. NO.
FIELDS SHUNT NO. TURNS SIZE WIRE DIMENSIONS STYLE NO.
" SERIES " " " " " " "
" AUX " " " " " " "
BRUSHES: MAKE NO. GRADE SIZE SHUNT TERMINAL BEVEL
BRUSHOLDERS: MAKE NO. STYLE NO.

CONTROL DATA

MAKE TYPE H. P. VOLTS DUTY SER. NO. DWG. NO.
RESISTANCE: MAKE TYPE NO. SECTIONS DWG. STYLE NO.
MASTER SWITCH MAKE TYPE VOLTS AMPS. DWG. SER. NO.
BRAKE SOLENOID: " " " H. P. WIRE SIZE TURNS SER. NO.

MISCELLANEOUS

PINION PATT DWG. ARMATURE BEARINGS PATT DWG. NO.
PULLEY " " JACK SHAFT " "
COUPLING " " BRAKE HUB. PATT DWG. BRAKE WHEEL PATT DWG.

1

TEST DATA

POT. TRANS. RATIO TO AMMETER COIL AMPS.
CUR. TRANS. RATIO TO SHUNT AMPS.
WM. POT COIL VOLTS MULTIPLIER (X):
WM. CUR. COIL AMPS.

FORMULAE
A.C.
AMPS.(I): A × X
WATTS. : W × X
V A : $\frac{A^1 + A^2}{2}$ × E × 1.732
H.P.: $\frac{\text{WATTS}}{746}$
D.C.
WATTS. : E × I
H.P. : $\frac{\text{WATTS}}{746}$

E	A^1	A^2	W^1	W^2	Amps 1	Amps 2	Watts 1	Watts 2	Total Watts	Volt Amps	P.F.	R.P.M.	REMARKS

Saving $740 in Equipping Yard Locomotives With Electric Headlights

IT BECAME necessary to equip our two yard locomotives with electric headlights in order to operate them on night shift at the plant with which the writer is associated. Due to the fact that this night work is to continue only during the current year, we hesitated to purchase the usual steam turbine headlight generator, as the cost was rather high. Such a unit would cost about $400.

The Electrical Department suggested the installation of a storage battery on each locomotive together with 6-volt headlights such as are used on automobiles. This suggestion was adopted and the necessary material purchased. Two spare batteries were purchased; so it was a matter of only a few minutes to remove the used battery twice a week and replace it by one fully charged.

A headlight was placed on each end of the locomotive. Double-filament lamps were used and connected so that when the front light is bright (32-cp. filament in use) the rear light is dim (2-cp. filament in use) and vice versa.

It was found that the batteries gave bright illumination for a period of three nights, so the batteries are now changed twice a week—on Monday and Wednesday. The batteries are charged from a d.c., 110-volt exciter which operates constantly in supplying field excitation for a large synchronous motor. A resistor is used to cut down the flow of current into the batteries. The entire cost of this installation was less than $60 for two locomotives. Turbine generator units would have cost at least $800 for the two locomotives; hence there was a saving of $740 obtained in using the method described.

CHARLES A. PETERSON.

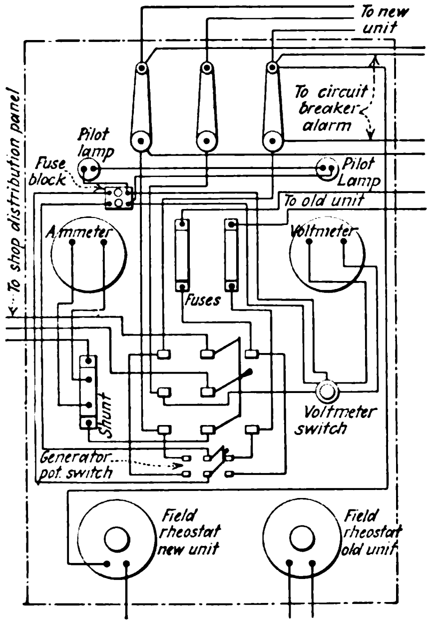
Chief Electrician,
U. S. Gypsum Co.,
Alabaster, Mich.

Layout of Panel to Control Two Generators

THE recent installation of a new, engine-driven generator in our factory power plant made necessary the construction of a special switchboard panel to accommodate both the new unit and the one it superseded. The old generator is now used as a stand-by.

The new unit is a 230-volt, 150-kw., direct-current Ridgeway generator of the three-wire type, whereas the old 75-kw. generator is of the two-wire type. The difference in types of generators made necessary the use of a three-pole, double-throw main switch with only two clips on the side which is connected to the old generator. The latter is protected by 400-amp. fuses, whereas the new generator is protected by an ITE circuit breaker of the three-coil type, the neutral calibration being 125 to 175 amperes. Two conditions are responsible for this arrangement: First, the fact that the new unit requires a circuit-breaker having a range of 600 to 900 amp., which would be more than 50 per cent overload on the old set; second, the old unit is used so rarely as to make the matter of an occasional blown fuse not objectionable from the standpoint of time lost or cost of fuses.

The Weston voltmeter, 0 to 300 volts, and the two pilot lamps are protected by the same set of 3-amp. fuse plugs. The voltmeter is connected to a small, double-pole, double-throw knife switch which enables it to be transferred from one generator to the other as required. This arrangement also makes it possible for the generator voltage to be adjusted to its proper value before the main switch is closed.



Either generator can be cut into service by throwing the double-throw switch to the proper position.

Inasmuch as the old two-wire generator is run only infrequently, fuses are employed for overload protection. An ITE circuit breaker is used to protect the new three-wire generator.

The voltmeter circuit for the new three-wire generator contains a Westinghouse drum-type voltmeter switch which makes it possible to read successively the voltage on each side of the neutral and across the outside mains.

The Weston ammeter, 0 to 1,000 amp. capacity, is connected to a shunt, and is calibrated to read directly. Special, slotted terminals are used to connect the shunt in the main circuit.

The circuit breaker alarm device described on page 37 of the January, 1922, issue of INDUSTRIAL ENGINEER is connected as shown in the diagram.

The switchboard panel is made up of four sections of 16-in. x 40-in. x 1½-in. purple slate, mounted on angle irons which are bolted to projecting angles embedded in the floor.

The cost of all the material used in the construction of the panel, including instruments, was $586.16. The labor cost was $70.43, which included laying out and drilling of the slate panels and angles, mounting and wiring of instruments, and erection of the board in the engine room. The field rheostats and old generator fuses are not included in the above cost of material because they were, in one case, on hand, and in the other the new generator rheostat was supplied with the unit.

J. M. WALSH.

Asst. Chief Engineer,
Gurney Elevator Co.,
New York, N. Y.

European Practice in Laying Steel-Armored Cables

RECENT discussions in INDUSTRIAL ENGINEER give the impression that underground, steel-armored cables are not widely used in American industrial plants. In Europe, however, it is general practice to use them on voltages up to 15,000, which is usually the highest voltage to be found inside an industrial plant.

In order to obtain good results from underground cables, great care should be given to the installation, which should preferably be done by an experienced crew. The standard practice in Europe is to lay the cables in a trench 32 in. to 36 in. deep, and not less than 20 in. wide at the bottom. A layer of sand about 2 in. thick is first spread over the bottom of the trench, and the cables are then laid in and pulled straight by men placed at intervals. For long lengths of cable, this procedure requires a large number of men, but it has been found safer than mechanical methods of pulling for they usually endanger the life of the cable. After the cables are laid, a second layer of sand about 4 in. thick is placed over them. Bricks are then laid over the sand to indicate the presence of the cables and to prevent the workmen from injuring them when digging again later. The trench is then filled in.

Sharp bends should be avoided and when changing direction the inside radius of the bend should not be less than 12 times the diameter of the cable. Underground cables should not be installed during freezing weather, because if they are subjected to cold the jute or impregnated paper, which forms the insulation, will crack and later cause breakdowns to ground.

When two cables have to be joined together, each end is stripped of all the insulation and brought into a cast-iron junction box. The conductors of the same polarity are joined by a copper sleeve and soldered. After the conductors are spread apart, the ends of the box are firmly tightened, and the box filled with insulating compound.

In power houses and substations every cable terminal is provided with a cast-iron terminal box. The bare conductors are spread apart in the box, which is then filled with insulating compound, the leads coming out through porcelain insulators.

Cable manufacturers give data which indicate the allowable load (in amperes) for each type of cable according to its cross-section. When more than two cables are placed in the same trench it is advisable to decrease the rating in amperes given by the manufacturer in the ratio of 1 to 0.75.

If underground cables are properly handled, they will last for a long period of time. I have seen such cables, installed in 1902, whose double steel tape had disintegrated by rust, but which were still giving service.

P. VAN HERK.

Bressoux, Liege, Belgium.

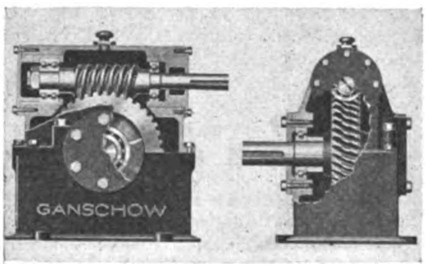
New Equipment

for plant operation and maintenance

Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these new devices which are designed to improve plant operation or reduce operating and maintenance costs.

Worm Gear Speed Reducer

ANNOUNCEMENT is made by the William Ganschow Co., 18 N. Morgan St., Chicago, Ill., of improvements in the types of their fully-enclosed, worm gear speed reducers which have been placed on the market recently. Standard units are equipped with gears of special bronze which, it is



stated, give an increased load-carrying capacity. The worm is made of 3½ per cent nickel steel, which is hardened and ground all over.

Either ball or roller bearings can be fitted to the unit according to the service demands. The gear bearings are held in place by means of clamping plates, as in the duplex worm thrust bearing. The front radial worm bearing is free to float which compensates for expansion due to heat. The cast-iron housing forms an oil reservoir into which the gear dips.

Self-Start Squirrel Cage Motors

TWO new, improved types of self-start, squirrel-cage, induction motors have been announced by the Imperial Electric Co., Akron, Ohio, after two years of intensive shop and field tests on them.

According to the manufacturer, the high-torque, self-start motor, Type EH, will deliver 175 per cent of full-load running torque to start, which value will rise, after the motor begins to revolve, to a value approximating 250 per cent. This motor will keep down the inrush of current at starting within the limits established by the National Electric Light Association and can, therefore, be installed and started across the line with enclosed, safety, hand-operated switches or with magnetic switches actuated by push buttons, float valves, pressure regulators and other similar devices. Sizes larger than 5 hp. have a double squirrel-cage rotor and are intended for installations requiring very high starting torque.

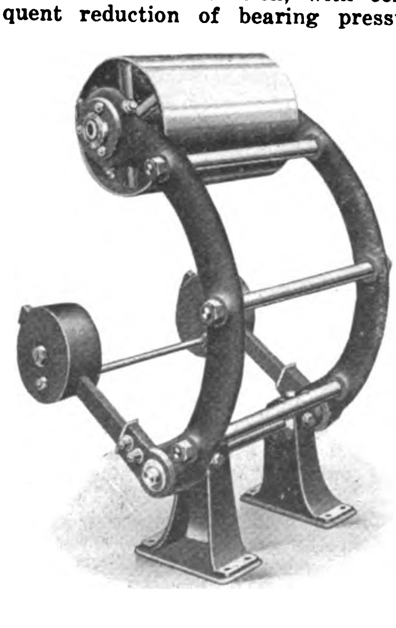
The Type EN self-start, normal-torque, squirrel-cage motor is designed to have a starting torque equal to that of a standard squirrel-cage motor connected to the highest tap on the compensator. The torque rises to a value in excess of 200 per cent of full load as the motor approaches its full speed, which characteristic is, according to the manufacturer, an improvement over self-starting motors whose torque drops off after the rotor starts to revolve. This type is especially adapted for installations requiring normal starting and high pull-out torques.

Short-Center Belt Adjuster

IDLER pulleys with swinging arms and weights to provide a constant, uniform tension on the flat side of the belt are announced by The Medart Co., Potomac and De Kalb Sts., St. Louis, Mo., under the name of Medart Short-Center Belt Adjuster. This device is shown in the accompanying illustration. It also shows the method of applying pressure to the idler pulley which takes up the slack in the belt.

The idler pulley may be equipped either with bronze bushings or anti-friction bearings. The pivot for the swinging arm may be adjusted. The idler pulley automatically swings between the driving and the driven pulley and is placed so that it will wrap the belt around the pulley, and thereby increase the arc of contact.

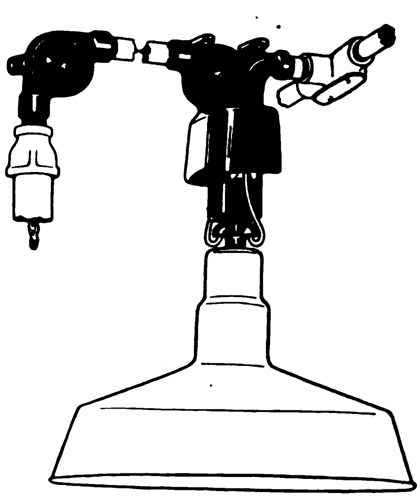
Some of the advantages claimed for this device are: elimination of belt slipping; increased life of belt; saving in floor space; the use of pulley ratios as high as 20 to 1 on short centers; and decrease of belt tension, with consequent reduction of bearing pressure.



Safety Lowering Switch

A NEW model safety lowering switch has been placed on the market by the Thompson Electric Co., of Cleveland, Ohio. This device has been developed for disconnecting and lowering lighting fixtures that are located in places which are exceptionally dirty. It differs from previous models of the safety lowering switch, in that there is no external opening in the sheave housing to admit dirt or corrosive elements. The galvanized sheave wheel is inserted through the side of the housing, making it easy of inspection without disturbing the installation in any way.

Another new feature is that provision is made whereby the conduit for inclosing the chain, and also the conduit for inclosing the wires, can be screwed straight into the sheave housing on the



ceiling or girder line, thereby making the lowering switch an integral part of the conduit system. When placed at right angles to a line of conduit, as shown in the accompanying illustration, a T-shaped conduit fitting and a short nipple will serve to bring the wires into the hanger.

Inclosing the chain in conduit is important, for three reasons: First, the chain will be safeguarded against accidents from contact with belting or other moving apparatus, even though it extends directly through a dangerous zone. Second, the chain will be protected from corrosive elements. Third, it greatly improves the appearance of the installation.

Use of this new model of lowering switch will naturally call for the use of the totally-inclosed corner pulley No. 149, shown in the accompanying illustration, which provides for turning the direction of the chain through a right angle.

Sign Illuminator

A SIGN illuminator made entirely of cast aluminum alloy and designed to thoroughly illuminate a standard 10-in. by 14-in. enameled sign, has recently been placed upon the market by the Nichols-Lintern Co., 7960 Lorain Ave., Cleveland, Ohio. This illuminator is particularly designed for use in industrial plants for illuminating danger signs. Although designed for a standard size of sign it can be readily

altered to illuminate signs of other dimensions.

This illuminator is wired for two 25-, 40-, or 50-watt lamps and throws a powerful beam of light through two 4-in. clear convex roundels on to the sign beneath. Two red or yellow lenses are used on the front panel. These

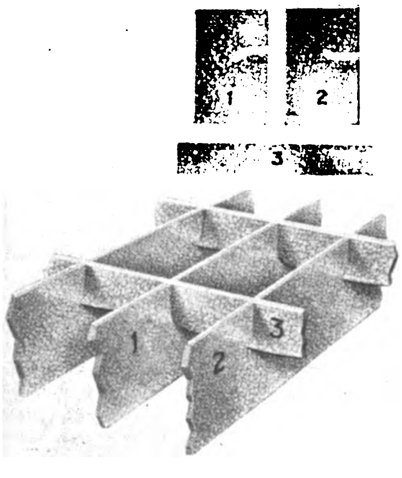
lenses serve to attract attention or catch the eye much quicker than the ordinary illuminated sign.

It is dustproof and very rugged and the construction is such that the installation and maintenance is simple. In changing lamps there are no screws to remove, as the lamps become accessible by merely pulling two pins which are fastened to a chain. It is drilled and tapped on each end for ½-in. conduit.

Steel Grating and Tread

A NEW steel grating and tread known as Tri-Lok has been put on the market for the Tri-Lok Company, 5527 Butler Street, Pittsburgh, Pa. There are several distinguishing features to this grating. First, there is a right twist lock in every other bar. Bar *1* in the accompanying illustration shows how this is done. On alternate bars there is a left twist as shown on bar *2* of the accompanying illustration. Into these two reverse twists is forced a third bar, marked *3* in the accompanying illustration, by a 1,600-ton hydraulic press. This action locks the bars together as shown in the lower part of the illustration.

Another interesting feature is that there are no acute angles formed by the bars with the result that there is a maximum of ventilation and light, a total of 90 per cent of the area covered being open. Inasmuch as there are no rivets or bolts the manufacturer states that this grating, therefore, cannot loosen.



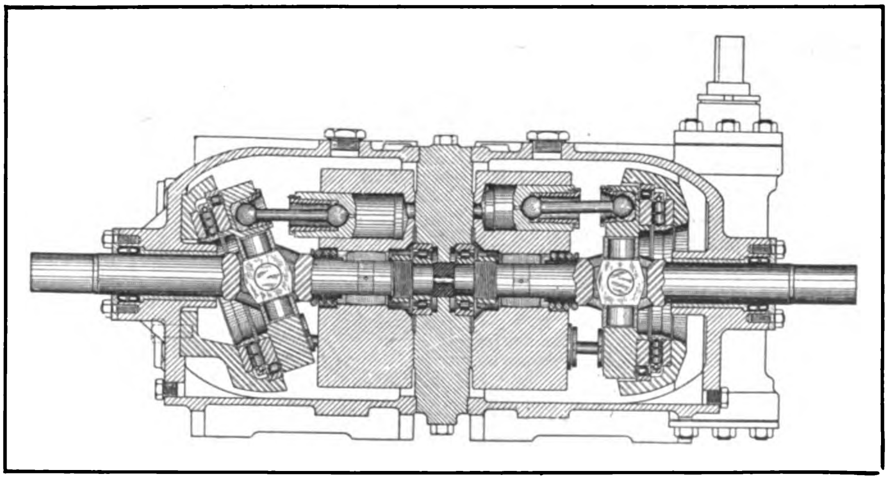
Universal Hydraulic Variable Speed Gears

ANNOUNCEMENT is made by the Waterbury Tool Co., Waterbury, Conn., of the application of the Universal hydraulic, variable-speed gear to industrial service. This unit has been in use for a number of years for various purposes in the U. S. Navy. Recently attention has been given to the application of these drives on paper mills and other industrial equipment.

The Universal hydraulic, variable-speed gear, is, according to the manufacturer, a machine for transmitting rotary power at variable speeds and in either direction without stops or abrupt gradations while the source of power rotates continuously in one direction without any necessary change of speed. This source may be an engine, motor, shaft, or other rotating mechanism from which it is desired to transmit power. Oil is used as the medium through which power is transmitted.

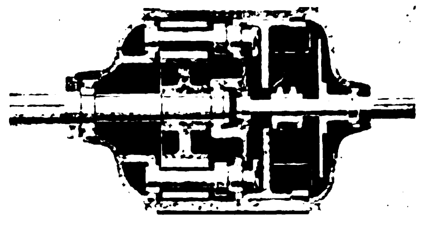
The machine, a cross-section of which is shown in the accompanying illustration, consists of two separate units designated respectively as the *A* end and the *B* end. The *A* end is an oil pump operated by the driving power. Its function is to deliver oil to the *B* end at any required pressure and to receive it back again, thus keeping up an oil circulation. The *A* end contains a controlling device by which the quantity of oil delivered to the *B* end is regulated to meet the speed requirements of the *B* end.

The driven shaft, at *A* end, is supposed to rotate continuously in one direction, which may be either right-hand or left-hand. The *B* end is a hydraulic motor with its rotating parts very similar to those of the *A* end. In its capacity as a motor, its shaft rotates at any speed and in either direction in obedience to the quantity and direction of delivery of the oil it receives from the *A* end. The device is made in five sizes with working ratings of 15, 30, 50, 100, and 200 hp.



Variable Speed Reducing Unit

TO MEET the increasing demand for variable-speed drives for conveyors, cement mills, machine tools and other machinery requiring adjustment of speed, William E. Simpson, of Highland Park, Mich., is putting on the market a new line of speed reducers which embody, in a single compact unit, a variable-speed drive.



Each unit comprises two reductions only, the first being a modified worm movement with variable ratio, and the second a train of heavy spur gearing adapted to take the heavy torque and shocks of the slow-speed end.

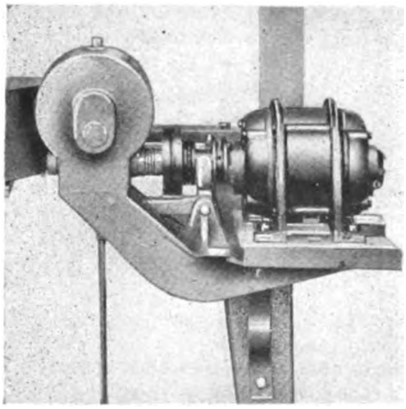
It is stated by the manufacturer that these reducers will operate silently and efficiently at motor speeds up to 3,600 r.p.m. and that the ratio can be readily adjusted from 10:1 to 1,000:1.

Utility "Motor-It" Speed Reducer Unit Drive

UNIT drives which contain the motor, flexible coupling or clutch, and a speed reducer so designed and mounted as to facilitate their attachment to machines, are being marketed by the Utility Manufacturing Co., Cudahy, Wis., under the trade name of "Motor-It." For continuous operation, a clutch is supplied. For short, intermittent operation a disk clutch, operated by means of a foot lever, is used for connecting the motor to the speed reducer, as is shown in the accompanying illustration. For longer, intermittent operation, an expanding-type clutch is used. An 1,800-r.p.m. motor, clutch and reduction gear are standard equipment. The motor is supplied in ¼-, ½-, ¾-, 1-, 1½-, and 2-hp. sizes.

Reduction gears of any specified ratio may be obtained. Speed reduction is obtained by means of a worm and a wheel or spiral gear. Either roller or ball thrust bearings are used. It is

stated that these units can be applied to any type of machine now driven by means of a belt or gear. The Motor-It unit can be put on the shaft in place of the tight and loose pulley or clutch, as



the unit is bored to fit the customer's shaft. The gear set is completely enclosed and the entire unit is mounted on a cast base.

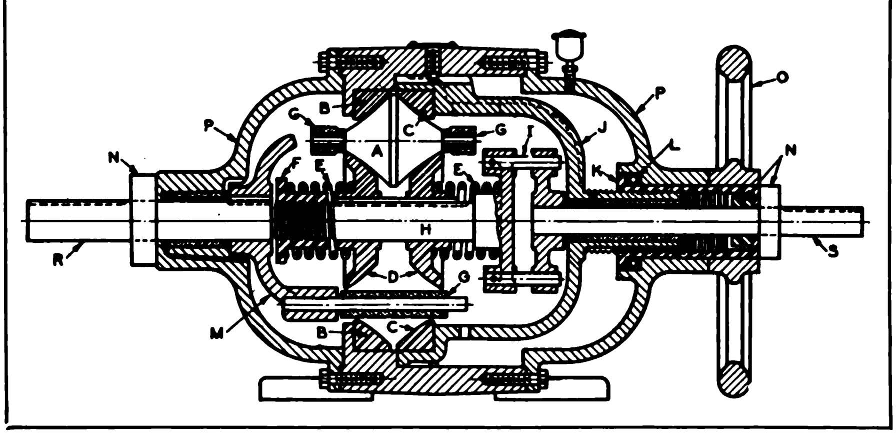
Variable-Speed Transmission

ANNOUNCEMENT is made of the development and manufacture by the Columbia Vari-Speed Co., 4020 Lake Street, Chicago, Ill., of a new type of mechanical, variable-speed transmission known as the JFS Variable Speed Transmission Unit. It consists of a high-grade roller bearing totally enclosed in a cast-iron housing and running in oil. To obtain a variable ratio of speed between the elements of the bearing, the rollers are given an unusual shape and provision is made for shifting the relative position of the races.

Power is transmitted through this unit by friction between extremely hard metal surfaces bearing against each other under high pressure. The operation as given by the manufacturer is as follows: The vital parts consist of three rollers (designated by *A* in the sectional view in the accompanying illustration) rolling around the outside of the two inner races *D*, and around the inside of the two outer races *B* and *C*. The inner races are rotated by the input shaft *S*, while the outer races are held from rotating. The rollers are, therefore, caused to move in planetary fashion around the axis of the machine, and at a slower speed than that of the inner races. Each roller is mounted in a yoke *G* which in turn is mounted on the spindle *M*. The spindle is thus pulled around by the rollers and rotates the output shaft *R* to which it is keyed. The number of revolutions which the input races must make to cause the rollers to make one complete circuit depends on where the points of contact occur between the rollers and races. These may be shifted at will by rotating the handwheel, which varies the ratio of speed between the input and output shafts. Lubrication of moving parts is obtained by a splash system.

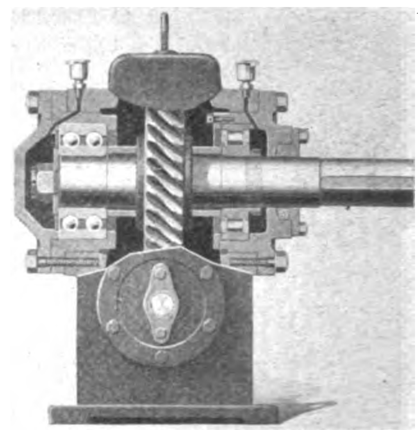
This unit is manufactured in two types. Type *R* variable-speed transmission gives a minimum speed reduction of 9:1 with a maximum variation of 5:1. For example, if the unit is connected to an 1,800-r.p.m. motor, the output shaft will have a maximum speed of 1,000 r.p.m., and a minimum speed of 200 r.p.m., and any speed ratio desired between these limits. Where a greater average reduction is desirable, the Type *RG* unit is used, which has a 5:1 planetary gear built into the output end of the unit. This gives an additional reduction of 5:1, so that if driven by an 1,800-r.p.m. motor, the range of output speeds would be from 200 r.p.m. down to 40 r.p.m. These units are manufactured in capacities up to 7½ hp. at present.

It is stated that the construction is such that units which have been in operation for a considerable length of time show no evidence of wear on the races or rollers, due to the fact that an especially hard metal is used for these. The output shaft may be direct-connected to the machine and driven by the use of a flexible coupling or through a belt, chain, or gear drive. In the latter cases an outboard bearing is furnished with the reducer. If the unit is mounted overhead where it is not convenient to get at the control wheel, it may be placed at any desired point and connected to the unit by a chain and sprocket.



Worm Gear Speed Reducer

ANNOUNCEMENT is made by the Philadelphia Gear Works, Richmond and Tioga Sts., Philadelphia, Pa., of the marketing of the Type AX worm gear speed reducer shown in the accompanying illustration. The construction, as described by the manufacturer, is as follows: The worm is made from low-carbon, nickel-alloy steel forged integral with its shaft. The worm threads are hardened and ground and the worm shaft is mounted on ball bearings for taking thrust in both directions, as well as radial loads. The worm gear is made of steel cast bronze shrunk and securely fastened to cast iron spider. The worm



wheel shaft is made of nickel-alloy steel, heat-treated and ground, and the no-load end is mounted on a double-row ball bearing for taking thrust in both directions. The load end of the worm wheel shaft is mounted on a Norma Hoffman roller bearing which is designed to compensate for overhung loads such as pinion, pulley, or sprocket drive, thus eliminating the necessity of providing an extension on the worm wheel shaft for an outboard bearing support.

Manufacturers of Power Transmission Equipment Form Association

THE Survey Committee appointed at a meeting of belting, transmission and accessory manufacturers, held in Cleveland on June 10th, met at the Old Colony Club, Waldorf-Astoria, New York, on September 14th with practically a full committee present. Reports of the Chairman and Secretary indicating a great deal of interest in the proposed movement were submitted, and the matter of further procedure was taken up in considerable detail.

As the result of considerable investigation by the Chairman and Secretary, suggestions were made to the Committee that instead of the preliminary survey that was to be made in accordance with the decision reached at the Cleveland meeting, it would be better to lay the groundwork at this time for an Association, making at the same time a survey which would determine the procedure to be followed upon the final organization of the Association, and then when such an organization is formed, to establish a Research Bureau and proceed along the lines laid down by the Organization Committee.

The matter of securing additional memberships was thoroughly discussed and the Organization Committee decided to constitute themselves a committee of the whole on membership, the secretary to furnish each member with a list of logical prospects in his terri-

tory. In this way everyone interested in such a movement, would be approached and informed fully as to the objects and purposes of the Association.

The Chairman was instructed by the full committee present, to appoint a sub-committee to report to the full committee on a name and outline the objects of the Association. The following members were appointed on this committee:

Geo. H. Fisher, Pres. Fisher Leather Belting Co., Philadelphia, Pa., chairman; Edward H. Ball, Pres. Chicago Belting Company, Chicago, Ill.; Wylie K. Lee, Pres. Clipper Belt Lacer Company, Grand Rapids, Mich.; F. E. Barth, Genl. Sales Mgr. Graton & Knight Mfg. Co., Worcester, Mass.; C. M. Murray, Pres. Transmission Ball Bearing Co., Buffalo, N. Y.; W. H. Fisher, Secy. and Sales Mgr. T. B. Wood's Sons Co., Chambersburg, Penna., Ex officio; W. W. French, Sales Promotion Manager Dodge Manufacturing Corp'n, Mishawaka, Ind., Ex officio.

This committee reported very favorably on the name, "Power Transmission Association," which was adopted.

The objects of the Association are: To promote the most efficient and economical distribution of power; to make a scientific study of all engineering problems connected with the transmission of power; to accumulate and compile accurate and authoritative information regarding the most economical and efficient power transmission methods and to place this information at the disposal of all power users through the members of this organization and through planned publicity; and to further the interests of affiliated manufacturers and their distributors making and handling power equipment.

The committee considered several propositions submitted to it bearing on the subject of making the survey, and it was decided to work this out further for submission at a general meeting, which was tentatively set for November, the exact date to be decided upon and announced later.

An aggressive attempt is being made to add many more firms to the list of about 80, who have contributed to the Association work up to the present time. The list of members is as follows:

T. B. Wood's Sons Co.; Medart Company; Moloney Belting Co.; Hans Rees' Sons; Page Belting Co.; E. F. Houghton & Co.; Rockwood Mfg. Co.; U. S. Leather Co.; Alexander Brothers; I. B. Williams & Sons; Graton & Knight Mfg. Co.; Clipper Belt Lacer Co.; American Pulley Co.; Bond Foundry & Machine Co; Royersford Foundry & Machine Co.; A. & F. Brown Co.; Security Rubber & Belting Co.; Chas. Bond Co.; Valley Iron Works; Standard Pressed Steel Co.; F. Raniville Co.; Shingle-Gibb Leather Co.; Transmission Ball Bearing Co; O'Meara Belting Co.; Meier-Andress Belting Co.; Ohio Valley Pulley Works; Fensholt & Fechner Co.; Baltimore Belting Co.; Bonner & Barnewell, Inc.; Chicago Belting Co.; Pyott Foundry Co.; Bay State Belting Co.; Kistler, Lesh & Co.; Cling-Surface Co; Schwartz Belting Co.; L. P. Degan Belting Co.; H. N. Cook Belting Co.; Holyoke Belting Co.; Chicago Pulley & Shafting Co.; J. A. Webb Belting Co.; Whiting Leather & Belting Co.; McAdoo & Allen; E. P. Alexander & Son; Fisher Leather Belting Co.; Plant Co.; Brown Clutch Co.; W. H. Salisbury & Co., Inc.; McLeod Leather & Belting Co.; Eagle Belting Co.; Eclipse Wood Pulley Co.; McCauley Belting Co.; Saginaw Mfg. Co.; California Belting & Supply Co.; Klinger-Dills Co.; Baldwin Belting & Leather Co.; Chicago Rawhide Mfg. Co.; Detroit Belt Lacer Co.; Bickford & Francis Belting Co.; Byrnes Belting Co.; Grand Rapids Belting Co.; Hide Leather & Belting Co.; Hudson Belting Co.; Chas. L. Ireson, Inc.; Jewell Belting Co.; Johnson Leather Belting Co.; Edward R. Ladew Co., Inc.; Laurence Belting Co.; Missouri Belting Co.; New York Leather Belting Co.; Norwich Belt Mfg. Co.; N. Palmer & Co.; Geo. Rahmann & Co.; J. E. Rhoades & Sons; Chas. A. Schieren Co.; Schwartz Belting Co.; Schultz Belting Co.; Union Belt Co.; Hyatt Roller Bearing Co.; Bay Belting & Supply Co.; Sawyer Leather Belting Co.

Owing to the fact that funds solicited by the committee in the first instance were for the definite purpose of making a survey, it was decided that a complete explanation of the purposes of the Association and the new measures proposed by the committee, would be sent out to the membership at once and their permission asked to follow the new course of procedure, rather than the one first decided upon.

Much enthusiasm was manifested over the work so far accomplished and W. H. Fisher, the Chairman, pointed out that with the membership already enrolled, plus the members of the Leather Belting Exchange, who have endorsed the movement and decided to go in as a body, the membership would be about 100; this, however, is not considered enough to insure the success of the Association in the rather extensive program mapped out, and the Committee will undertake to increase this number further before the general meeting, to which all those interested in the movement and who have contributed, will be invited.

Trade Literature

you should know about

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Dead-Ending Clamp—Bulletin 101 describes screw-jack dead-ending clamps for stranded cable and illustrates a number of installations. — The Clark Controller Co., 1146 E. 152nd St., Cleveland, Ohio.

Belt-Slacker — Helpful data to the engineer on the application and installation of this device on short center belt drives is given in leaflet Form B-28.—Harry M. Perry, 702 Main St., Los Angeles, Cal.

Leather V-Belt Drives—A circular shows the principles involved in Graton & Knight leather V-belt drives, and also illustrates various applications of such belts made by this company.—Graton & Knight Co., 356 Franklin St., Worcester, Mass.

Speed Reducers—A new catalogue describes the complete line of Philadelphia worm gear herringbone and spiral bevel herringbone speed reducers in any ratio for giving straight-line, right-angle, or vertical drives.—Philadelphia Gear Works, Richmond and Tioga Sts., Philadelphia, Pa.

Portable Elevator — Bulletin 90F shows how the portable elevators can be mounted and used for stationary work.—Revolvator Co., 336 Garfield Ave., Jersey City, N. J.

Speed Transformer—Bulletin 105 describes the Poole type H speed transformer. Bulletin 106 describes and illustrates the Poole type K speed transformer.—Poole Engineering & Machine Co., Baltimore, Md.

Flexible Coupling—Bulletin 107 illustrates and describes the various types of Poole flexible couplings, which can be used for continuous or reversing service at high or low speeds. Bulletin 108 describes in detail the various parts of the Poole flexible couplings.—Poole Engineering & Machine Co., Baltimore, Md.

Grease—A 28-page booklet entitled, "Densities and Uses of Keystone Grease," contains an application chart which gives a partial list of machinery lubricated with Keystone grease and indicates the methods of application as well as the recommended densities.—Keystone Lubricating Co., Philadelphia.

Lubricator—An 8-page booklet describes the Knorr lubricator, which is designed to feed grease automatically to the shaft while it is in motion.—Knorr Lubricator Sales Co. of New England, 80 Federal St., Boston, Mass.

Belt Dressing—A 16-page booklet entitled, "The Proper Care of Belts," discusses belts and their care, and describes the various Dixon belt dressings, with their application.—Joseph Dixon Crucible Co., Jersey City, N. J.

Carbon Products—Catalog B-4 is a 40-page, loose-leaf, pocket-size catalog of carbon brushes, and contains a description of each type and listing of sizes, together with directions for ordering brushes.—The United States Graphite Co., Saginaw, Mich.

Arc Welding Unit—Bulletin GEA-9 describes the gas-engine-driven type of arc welding units and Bulletin GEA-255, the stationary or portable, belt- or motor-driven arc welding units.—General Electric Co., Schenectady, N. Y.

Power Drive Data—An attractive, leather-bound booklet, vest pocket size, entitled "Guide Book of Drives," has just been published by the Link-Belt Co. This little volume gives a description of chain drives in general; chains compared with belts; the use of low- and medium-speed drives; roller chain drives; silent chain drives, including tables for use in ordering chains from 1- to 1,000-hp. rating at high speed; gear drives; belt drives; and simple arrangements for compound drives.—Link-Belt Co., 910 S. Michigan Ave., Chicago, Ill.

Drop Light—A folder describes the Triplex adjustable roller drop light and the Triplex drop extension light.—I. T. Gray & Co., 522 Fifth Avenue, New York, N. Y.

Portable Electric Drills—A new catalogue describes the various sizes and types of Wodack portable electric drills. —Wodack Electric Tool Corp., 23 So. Jefferson St., Chicago, Ill.

Micarta—A 24-page booklet, entitled "A Material of Endless Possibilities," contains information about this material and the many uses to which it has been put and indicates the possibilities for other applications.—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

New Substation—Bulletin 2056 describes and shows the layout of the new Pittsburgh Transformer Company's substation at their Manchester plant.—Pittsburgh Transformer Co., Pittsburgh, Pa.

Welding and Cutting Equipment—A 32-page, pocket-size junior catalog illustrates, describes briefly, and prices the various welding and cutting equipment manufactured by this company.—Smith Welding Equipment Corp., 2619 Fourth St., S. E., Minneapolis, Minn.

Heating Units—Bulletin C-106 illustrates and describes Chromalox heating units, and gives tables useful in their application. Booklet C-105 shows many applications where Chromalox heating units can be used.—Edwin L. Wiegand Co., 422 First Ave., Pittsburgh, Pa.

Power Transmitting Appliances—Catalog 4 lists, describes, and prices the various hangers, bearings, countershafting supplies and other equipment manufactured by this company.—Standard Pressed Steel Co., Jenkintown, Pa.

Oil Purification—A circular describes the De Laval method of purifying transformer and switch oil, and shows views of various installations of purifying equipment.—The De Laval Separator Co., 165 Broadway, New York, N. Y.

Portable Saw Table—A folder illustrates and gives the advantages claimed for the new portable table-mounted Wonder Saw which is designed for either electric or gasoline motor drive. —St. Louis Machine Tool Co., 1429 Pine St., St. Louis, Mo.

Gas Welding and Cutting Apparatus—Catalog 40 illustrates, describes, and prices the wide range of welding and cutting torches, attachments and regulating equipment manufactured by this company. — The Bastian-Blessing Co., 240 E. Ontario St., Chicago, Ill.

Push Button Magnet Controller—A folder illustrates, describes, and gives the advantages claimed for the Ohio magnet controller and master switch for use in connection with the rapid operation of electromagnets. A limited reverse current applied automatically, it is stated, causes the magnetism to drop to zero and the load to drop promptly.—The Ohio Electric & Controller Co., 5900 Maurice Ave., Cleveland, Ohio.

Air Hoists—A 16-page booklet illustrates a large number of applications of the Turbinair portable hoists of 1-ton capacity.—Sullivan Machinery Co., 122 S. Michigan Ave., Chicago, Ill.

Cast-Iron Pulleys—A circular describes the qualities claimed for Pyott Red Face cast-iron pulleys and flywheels.—Pyott Foundry Co., 328 N. Sangamon St., Chicago, Ill.

Copper Covered Wire—A folder gives engineering data and wire tables on the use of Copperweld non-rusting guy, messenger, and span wire.—Copperweld Steel Co., Braddock P. O., Rankin, Pa.

Motor and Wire Data—A celluloid pocket card gives the ampere ratings of a.c. and d.c. motors at full load and also the allowable carrying capacities of wire.—Monitor Controller Co., Baltimore, Md.

Transformer Data—No. 8 of a series of data sheets discusses, "How to Determine the Proper Marking of Three-Phase Transformers," with special reference to Moloney transformers.—Moloney Electric Co., St. Louis, Mo.

Aluminum Paint—A booklet entitled, "Bitulumin," discusses aluminum paints and metal primers in the form of 77 technical questions with their non-technical answers.—Hill, Hubbell & Co., San Francisco, Calif.

Variable Speed Blower—Bulletin 36 contains numerous examples of installations of Wing Type EM variable-speed blowers for connection to heating equipment.—L. J. Wing Mfg. Co., 352-362 13th St., New York, N. Y.

Traveling Cranes—Bulletin 176 gives the standard building clearances for Whiting overhead electric traveling cranes.—Whiting Corp., Harvey, Ill.

Motors—New price lists give descriptive information and prices on Type RS repulsion-start, induction, single-phase motors and Type SC squirrel-cage induction polyphase motors.—Century Electric Co., 1806 Pine St., St. Louis, Mo.

Concrete Floor Treatment — Folder No. 1 contains a complete description and detailed specifications of treatments for hardening, dustproofing, and waterproofing concrete floors. These specifications are in loose-leaf form, mounted in a binder. The general index covers integral hardeners, surface hardeners, concrete coatings, concrete accelerators, and freeze-proofers. — The Master-Builders Co., Cleveland, Ohio.

Molybdenum Ball Bearings — An 8-page folder entitled "Molybdenum Means More Life in 'Em," discusses the development and use of molybdenum steel for SRB forged balls in single- and double-row angular ball bearings. —Standard Steel & Bearings Co., Inc., Plainville, Conn.

Mechanical Rubber Goods—A series of booklets bound in a loose-leaf folder describe Goodrich rubber belting, transmission belting, conveyor belting, air and other hose and other mechanical rubber products and give applications and operating data.—The B. F. Goodrich Rubber Co., Akron, Ohio.

Starting Switch—Bulletin 105 describes the Clark starting switch which is designed to start and stop small induction motors that require a full load current of 3½ amp. or more.—The Clark Controller Co., 1146 E. 152nd St., Cleveland, Ohio.

Hand Truck—A 20-page, pocket-size catalog describes and illustrates the line of two-wheel pressed-steel hand trucks which are made up in nine different styles in 25 sizes, covering the ordinary hand truck requirements.—The American Pulley Co., 4200 Wissahickon Ave., Philadelphia, Pa.

Porcelain Insulators—A monthly publication entitled, "Thomas Topics," is devoted to descriptions of various Thomas porcelain, insulating products and other interesting information.—The R. Thomas & Sons Co., East Liverpool, Ohio.

Centrifugal Drive—Circular GEA-302 illustrates, describes and gives the operating characteristics of the G-E vertical, variable-voltage, direct-connected, squirrel-cage motor for centrifugal drives.—General Electric Co., Schenectady, N. Y.

Texrope Drive—Bulletin 1228-D describes the application and shows illustrations of a number of applications of the Allis Texrope drive, which consists of a textile base, multiple belt, operating in grooved sheaves for close-center drive.—Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Power Transmitting Appliances — Catalog G contains 288 pages and covers the complete line of power-transmitting appliances, ball and roller bearings, conveying and elevating machinery, and miscellaneous factory equipment manufactured and distributed by this company.—Chicago Pulley & Shafting Co., 17-23 N. Desplaines St., Chicago, Ill.

Safety Switches—A monthly house organ entitled, "Trumbull Cheer," describes Trumbull equipment and up-to-date installations, and contains other interesting information.—The Trumbull Electric Mfg. Co., Plainville, Conn.

Condulet Branch Extensions—Bulletin 2087 describes the OCB Condulet Branch Extensions which provide a means for making extensions to existing conduit installations by bridging from one condulet to another through the cover opening, thereby making it unnecessary to alter or cut into the existing conduit line. — Crouse - Hinds Co., Syracuse, N. Y.

Power Transmission Equipment — Catalog 26, which is printed in three sections, covers the line of power transmission equipment manufactured by this company. Section A is on flexible couplings; section B covers the application of clutch pulleys, cut-off couplings, and related equipment; section C covers rope drives, gears, speed transformers, and contains a large amount of useful engineering information. — The Hill Clutch Machine & Foundry Co., Northeast Corner Breakwater Ave. & West 55th St., Cleveland, Ohio.

INDUSTRIAL ENGINEER

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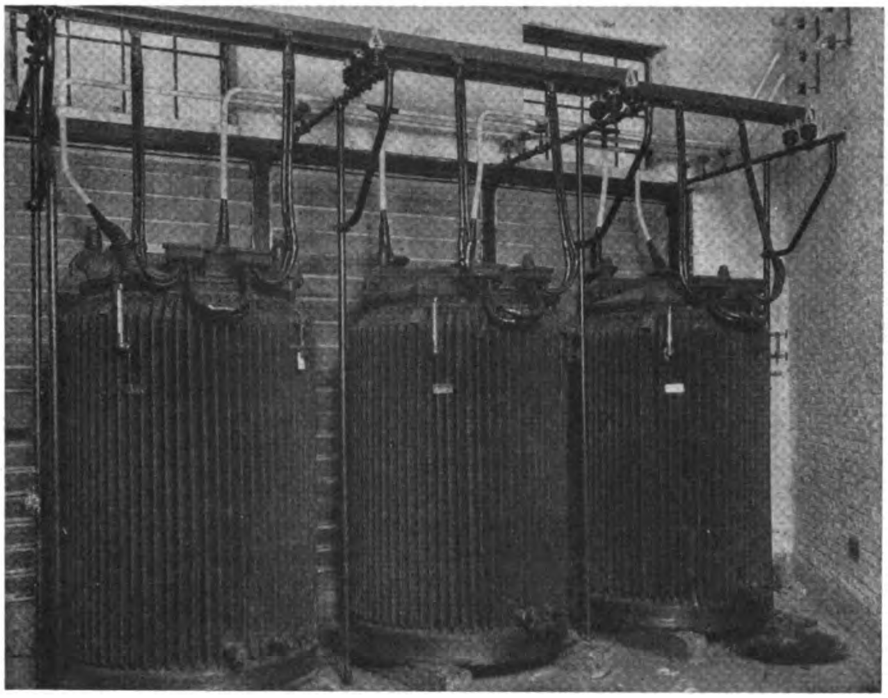
This is a standard industrial type of power transformer installation.



The delta connection is used on both the high and low tension sides.

Connecting Transformers to Three-Phase Circuits

By L. F. GOSS
Chief Engineer, Kuhlman Electric Co., Bay City, Mich.

TRANSFORMERS are an inherent necessity in the transformation of power so that it can be safely and economically used throughout the industrial plant. Because the transformer performs its duty without motion of its operating parts, it is often thought of as being of lesser importance in the problem of supplying power to the individual machine in the plant. However, the transformer is to the potential of electric power what the speed reducer, chain, or belt is to rotary motion. When consideration is given to the amount of power that can be handled by the transformer as compared to the usual types of speed reducers, chains or belts, the importance of the transformer in the industrial power problem is more easily grasped.

Transformers of present-day manufacture have very reliable and efficient performance. To the man buying or operating industrial transformers, ever-present problems are: What manner of transformer connections will best fit the requirements? How may transformers be operated in parallel? Factors that should be considered in the purchase of a transformer. Considerations affecting transformer efficiency, regulation and power factor. With these points in view, this article has been prepared to present, briefly and concisely, data that will aid the purchaser or operator of transformers.

In deciding the question of what method of transformer connection will best fit the operating conditions of the plant, probably the best method of approach is to consider the advantages and disadvantages of the more common forms of connection.

The connection that is most commonly used is the delta-delta, in which both the high-tension and low-tension sides of the transformer are each connected in series with each other or what is commonly known as

delta, as shown in Fig. 1. This connection is widely used for moderate transmission voltages. The reason that this method of connection is commonly preferred in industrial plants is given in (1) and (2) below:

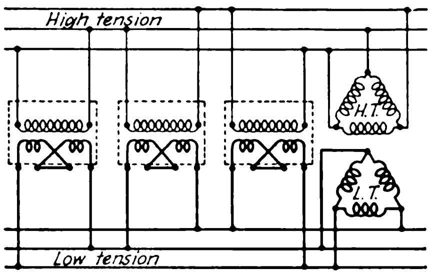


Fig. 1—Delta-delta connection of three single-phase transformers for three-phase service.

Advantages—(1) If one phase on either side becomes faulty, the remaining two phases can be operated in open-delta or V to give a three-phase output equal to 58 per cent of the total normal output. If, however, a number of delta-delta units or banks operate in parallel, the advantage as regards total output becomes less as the number of units or banks increase, since the sound banks do not supply their normal rated full load under these conditions.

(2) The delta-delta connection is the most economical connection for large-output, low-voltage transformers.

(3) Third harmonic voltages are eliminated by circulation of third harmonic currents in the deltas.

(4) It is one of the easiest connections to phase in for parallel operation.

(5) With balanced line voltages, no part of the windings can normally be at any excessive potential above ground, unless due to static charges.

(6) Large unbalanced three-wire loads may be given which only produce unbalanced voltages proportional to the internal impedances of the winding.

(7) In the case of three-phase, core-type units, if one phase should fail, due to an open circuit or low-tension ground only, both its primary and secondary windings must be disconnected from the other two phases and the sound winding (i.e. primary or secondary) of the faulty phase must be short-circuited. If the fault is due to a short-circuit betwen turns, however, the transformer should not be operated in V, as the damage is likely to extend to adjacent coils and possibly to the adjacent phase.

(8) If one phase of a three-phase shell-type transformer should fail, both the primary and secondary windings must be disconnected from the other two phases and the sound winding (i.e. primary or secondary) of the faulty phase must be short circuited.

(9) If one phase of three, single-phase, core- or shell-type units fails, the defective unit is simply disconnected and removed.

(10) Any three similar single-phase units may be connected delta-delta to form an emergency bank, providing their voltage ratios are the same.

Disadvantages—On the other hand the disadvantages of the delta-delta connection are the following:

(1) The copper section of both primary and secondary conductors is a minimum, the number of turns and total quantity of coil insulation per phase is a maximum, producing therefore a low copper factor and generally the least mechanically sturdy winding.

(2) No neutral points are available unless additional auxiliary apparatus be provided.

(3) A four-wire supply cannot be given unless additional auxiliary apparatus be provided.

(4) Three-phase units or banks of opposite polarity will not operate in parallel unless the meshing of either the primary or secondary phases of one transformer or bank be reversed.

(5) Coil construction difficulties are greater and costs are higher with high line voltages.

(6) Under normal operating conditions, the maximum pressure to ground on each phase is 58 per cent of the line voltage, the minimum pressure is 29 per cent and the average is 43.5 per cent. Insulation stresses are, therefore, somewhat higher than with the star connection.

(7) While theoretically it is possible to operate three-phase, core-type units in open delta with one phase damaged, it is very seldom practicable to do so.

(8) If the voltage ratios of the individual units of three single-phase core or shell type units are different, circulating currents will flow in the primary and secondary windings, the current being limited only by the impedance of the windings.

(9) If the impedances of these individual units are different, the load distribution between the units will be unequal.

In the star-star connection which is shown in Fig. 2 one lead of each high-tension winding is connected together to form a common or neutral point; the same is true of the low-tension windings. This type of connection has advantages which are listed in the following:

Advantages—(1) The cross section of both primary and secondary conductors is a maximum, the number of turns and total quantity of coil insulation per phase is a minimum, producing therefore a high copper factor and mechanically sturdy windings which

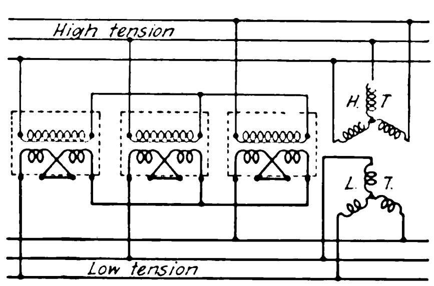


Fig. 2—This is a star-star connection of transformers.

are best able to withstand heavy external short circuits.

(2) It is the most economical connection for small output, high-voltage transformers.

(3) Both neutrals are available for

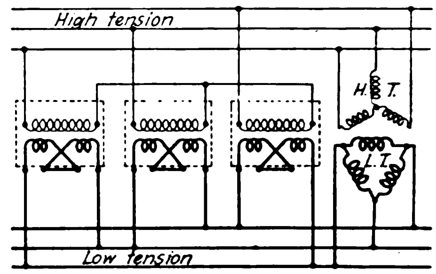


Fig. 3 — Connection scheme for transformers connected in star-delta.

grounding or for giving a balanced four-wire supply.

(4) It is one of the easiest connections to "phase-in" for parallel operation.

(5) Due to the relatively large conductors, the electrostatic capacity between turns is high, so that the severity of the stress, due to transient voltage waves striking the windings, is lessened considerably.

(6) If one phase on either side becomes faulty, the remaining two phases can be operated to give a single-phase transformation. The load supplied would be 58 per cent of the normal three-phase rating.

(7) If one phase of a three-phase, core-type unit fails, both its primary and secondary windings must be disconnected from the other two phases and the sound winding (i.e. primary or secondary) of the faulty phase must be short circuited. Under normal operating conditions, the maximum pressure to ground on each phase is only 58 per cent of the line voltage, the pressure grading down practically to zero at the neutral point. The average pressure to ground is 29 per cent of the line voltage. Insulation stresses are consequently a minimum. Third harmonic voltages are negligible, as a rule not exceeding 5 per cent of the fundamental. Either or both neutrals may be grounded.

(8) If one phase of a three-phase, shell-type unit fails, both its primary and secondary windings must be disconnected from the other two phases and the sound winding (i.e. primary and secondary) of the faulty phase must be short-circuited. Under normal operating conditions, the maximum pressure to ground on each phase is 58 per cent of the line voltage, the pressure grading down practically to zero, only provided the magnetic flux density does not exceed the value obtaining at the commencement of the "knee" bend of the B. H. curve. Either or both neutrals may be grounded only if the flux density value is in accordance with the foregoing.

(9) If one phase fails on three, single-phase, core- or shell-type units the unit is simply disconnected and removed. Under normal operating conditions, the maximum pressure to ground

on each phase is 58 per cent of the line voltage, the pressure grading down practically to zero, only provided the magnetic flux density does not exceed the value obtained at the commencement of the "knee" bend of the B. H. curve. Either or both neutrals may be

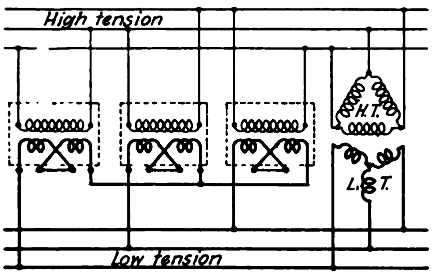


Fig. 4—Delta-star connection of single-phase transformers to transform three-phase power.

grounded only if the flux density value is in accordance with the foregoing. Differences in ratio and impedance of the individual units do not cause any appreciable unequal division of load or any circulating current.

Disadvantages—On the other hand the disadvantages of the star-star connection are as follows:

(1) The neutrals are inherently unstable unless solidly grounded.

(2) An unbalanced four-wire load cannot be given unless the primary and generator neutrals be connected together.

(3) Three-phase units or banks of opposite polarity will not operate in parallel unless the meshing of either the primary or secondary phases of one transformer or bank be reversed.

(4) A fault on one phase renders a three-phase unit or bank inoperative to give a three-phase supply, until the fault is repaired.

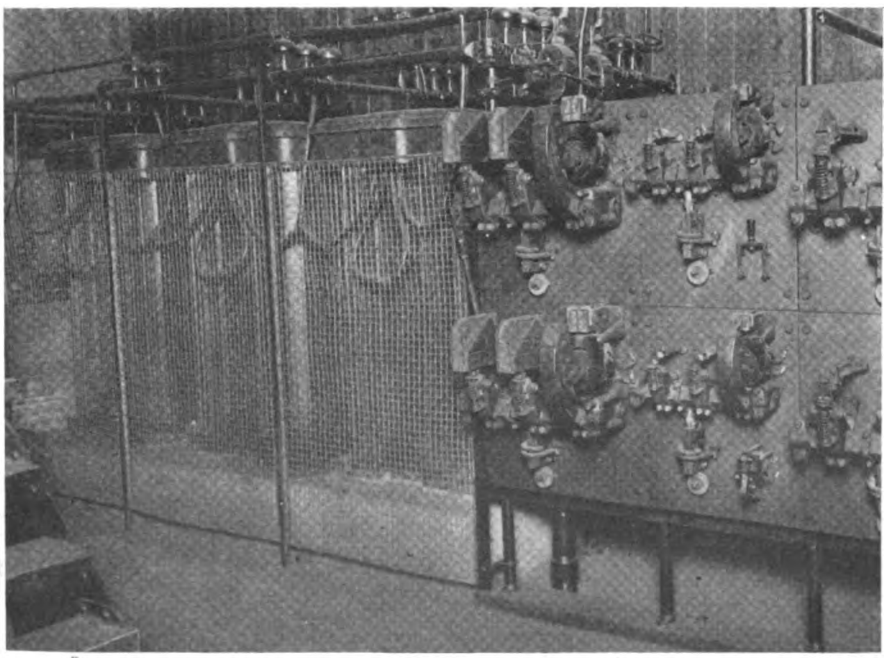
(5) Coil construction difficulties are greater and costs are higher with heavy line currents.

(6) In the case of a three-phase, shell-type unit third harmonic voltages as high as 30 to 60 per cent of the fundamental may be present at magnetic flux densities which are quite satisfactory for three-phase, core-type transformers. With isolated neutral, the stress from the neutral point to ground is consequently increased considerably as compared with the stress at the neutral of a three-phase, core-type transformer. If a grounding device is fitted to the neutral, the insulating medium must be proportioned according to the estimated third harmonic voltage at the neutral.

(7) Grounding the neutral of three-phase, core-type units transfers the third harmonic voltage vectors to each line terminal and the third harmonic voltages may be magnified by the resulting capacity current flowing through the inductance of the transformer windings. Telephone interference may occur if the neutral is grounded, particularly as both third and ninth harmonics of appreciable magnitude may be present.

(8) Generator and transformer primary neutrals should not be connected together as the third harmonic currents which would flow may also cause telephone interference.

Star-star connected transformers find the greatest scope of application as three-phase, core-type units for supplying relatively small power loads. In practice, it is generally difficult to insure a three-phase, four-wire lighting load being always balanced, and therefore this connection only finds a very limited field for such loads. For transmitting or distributing power in bulk, the connection is quite suitable from an operation standpoint, providing three-phase, core-type transformers are used, but three-phase, shell-type transformers and banks of single-phase transformers often introduce disturbances due to harmonics.



This 6,600/440-volt bank of transformers transforms the power for operating a hoist motor.

Another connection that is sometimes used is a combination of the

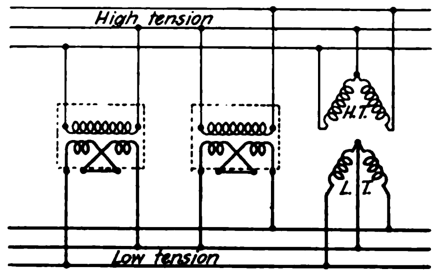


Fig. 5—The open-delta connection is used for connecting two single-phase transformers to transform three-phase power.

two that have just been described. This is known as the star-delta connection, in which the primary windings are connected in star while the secondary windings are connected in delta as shown in Fig. 3. This connection and the delta-star connection are often considered the best for high-voltage transmission systems. The following relates to the star-delta connection:

Advantages—(1) Third harmonic voltages are eliminated by the circulation of third harmonic current in the secondary delta.

(2) The primary neutral may be grounded.

(3) The primary neutral is maintained stable by the secondary delta.

(4) It is the most desirable connection for step-down transformers on account of the inherent characteristics of star windings for high voltages and delta windings for low voltages. See remarks under star-star and delta-delta connections.

Disadvantages—This connection has several disadvantages, however, which are given in the following:

(1) No secondary neutral point is available for grounding or for giving a four-wire supply unless additional auxiliary apparatus be provided.

(2) A fault on one phase renders a three-phase unit or bank inoperative until repaired.

(3) The delta winding may be mechanically weak in the case of a step-up transformer with a very high secondary voltage, or with a mediumly high secondary voltage and small output.

The chief application of this connection is for stepping down to supply a balanced three-phase load, such as motors.

The reverse of the connection just described, is the delta-star connection, which is shown in Fig. 4.

Advantages—(1) Third harmonic voltages are eliminated by the circu-

lation of third harmonic current in the primary delta.

(2) The secondary neutral may be grounded or it may be utilized for giving a four-wire supply.

(3) An unbalanced four-wire supply may be given and the resulting unbalanced voltages are relatively small, being proportional only to the internal impedances of the windings. Balanced and unbalanced loads may, therefore, be supplied simultaneously.

Disadvantages — On the other hand the disadvantages of this connection are:

(1) No primary neutral point is available for grounding. This is not necessarily a disadvantage, as the system on the primary side of the transformer is generally grounded at the generator or at the step-up transformer secondary.

(2) A fault on one phase renders a three-phase unit or bank inoperative until repaired.

(3) The delta winding may be mechanically weak in the case of a step-down transformer with a very high primary voltage, or with a medium-high primary voltage and small output.

The chief application of this connection is for stepping down to supply a four-wire load which may be balanced or unbalanced. With this connection, a combined load such as motors and lighting, can be given.

This connection is almost equally useful for stepping up to supply high-tension distribution or transmission lines, as third harmonic voltages are eliminated, the high-tension neutral is available for grounding and the high-tension winding possesses the most sturdy characteristics.

When three-phase transformation is required and use of only two single-phase transformers desired, the open-delta or the T-T connections may be employed. The open-delta connection is similar to the delta connection except that one transformer is omitted. This form of connection is shown in Fig. 5.

Advantages—(1) The only practical advantage is that some initial saving in cost may be effected when installing a transformer bank to supply a load which, though likely to grow, may not do so for some time. The transformer units must be single phase, either core or shell type, but two only need initially be installed instead of three for giving a three-phase supply.

(2) Third harmonic voltages and currents are usually very small with this connection and of no practical importance.

(3) For a given open-delta bank output the windings will be more sturdy than with the delta-delta connection for the same bank output, as the conductors must have a cross section proportioned for the full line current.

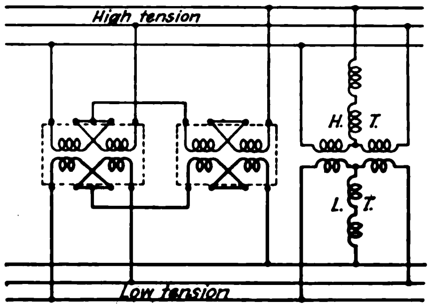


Fig. 6—By means of the T-T connection two single-phase transformers are capable of simultaneously supplying three-phase, two-phase, and single-phase power.

Disadvantages — The disadvantages of this form of connection are:

(1) While only two single-phase transformers need be installed, their rated kva. output must be 15.5 per cent greater than the total kva. load initially supplied. This is due to the 86.6 per cent internal power factor which occurs even with a unity power factor load.

(2) When the bank is converted to closed delta, the winding characteristics become identical with the delta-delta connection for the same bank output.

(3) No neutral points are available with this connection unless additional auxiliary apparatus is provided.

(4) Under normal operating conditions, the maximum pressure to ground on each phase is 58 per cent of the line voltage, the minimum pressure is 29 per cent, and the average is 43.5 per cent. Insulation stresses are, therefore, somewhat higher than with the star-connected winding.

(5) The connection is electrostatically unbalanced, and is therefore not suitable for high-voltage systems.

(6) Even with a balanced three-phase load, the load voltages become unbalanced to an extent depending on the impedance of the transformers and the load power factor.

(7) Due to the currents in the windings leading the voltage by 30 deg. in one phase and lagging by the same amount in the other, the power factors of the different phases of the system will become unbalanced. This will result in a flow of wattless current, the magnitude of which will largely depend upon the load power factor.

(8) Parallel operation of V-connected with delta-connected banks is uneconomical.

The only practical application that this connection has is enumerated under item (1) of *Advantages*. That is, under certain conditions the connection may be desirable on account of the saving in initial cost which may be effected when installing a bank to supply a load which, though likely to grow, may not do for some time. The connection has, however, not found much favor in this country.

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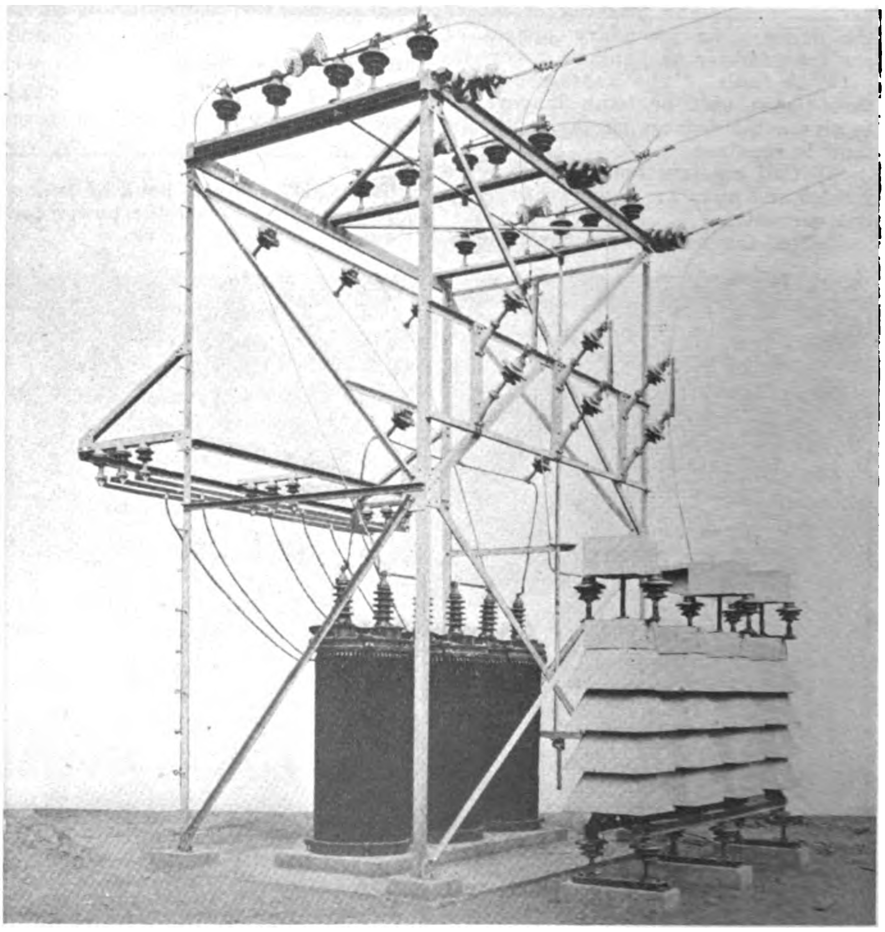


This outdoor transformer substation is in the plant yard of a large manufacturer.

Points to remember when

Erecting and Aligning a Lineshaft Drive

where the shaft must pass through walls or the installation presents unusual problems that require careful attention to details

By GEORGE TRIMM
Millwright Superintendent, Chicago Pulley & Shafting Co., Chicago, Ill.

THE article entitled, "Erecting and Aligning Lineshaft Drives," which began on page 398 in the September, 1926, issue of INDUSTRIAL ENGINEER, discussed the problems involved in the erection of a single length of shafting. Longer shafts are erected in the same manner. However, some additional complications are involved due to the extra length.

Irrespective of the length of the shaft, or how many sections of shafting are involved, the first step is to stretch the line which represents the center of the stringers for the feet of the hangers. The shaft is usually parallel with the wall and generally it is possible to align this center line by measuring from the wall at the two ends of the place where it is desired that the shaft be installed.

Care must be exercised to see that the wall is straight and also to see that measurements are not taken from a brick that extends in or out from the wall surface. Where the walls are not parallel, it is generally possible to select the end points of the lineshaft and stretch this line between these points.

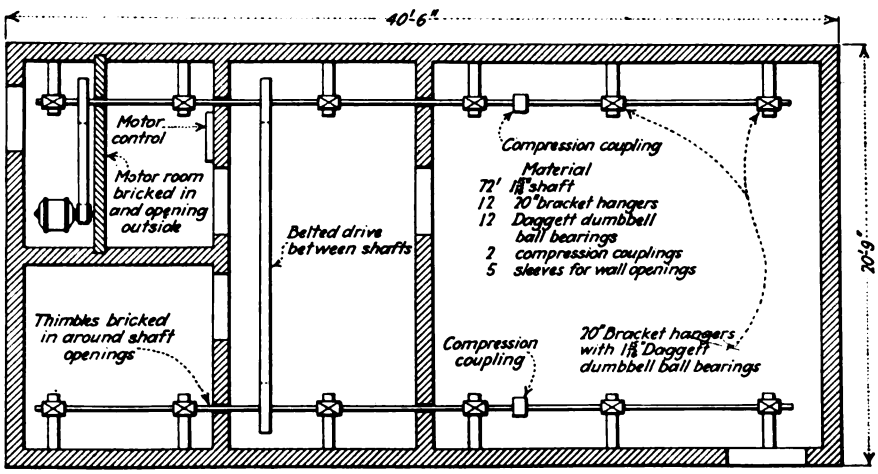
This center line is leveled so that the stringers can be kept as nearly level as possible. Of course, where the ceiling has considerable slope as was the case with the installation described in the September issue, a millwright must decide whether it will be better to bridge down from the ceiling to the stringer, so that it can be kept level, or to use hangers of different dimensions with the necessary blocking or staging beneath. This question should be decided from the standpoint of stability rather than economy unless the two or more types of construction under consideration are of approximately the same stiffness. The ability to hold the shaft in position even against the pull of the belt is the most important point in the construction. This consideration should be kept uppermost when laying the foundation or stringers to support the shaft, as the ease with which alignment is maintained is practically wholly dependent upon this foundation. Often the alignment of the lineshaft or the rigidity of this foundation depends, however, as much upon the stability of the building or the loading upon the floor above as it does upon any type of structure that may be built in to support the shaft.

After erecting the stringers the next step is to place the hangers. These are leveled from a new line stretched alongside the two end hangers and approximately parallel to the line where the shaft is to be placed.

This line is leveled with a line spirit level and the hangers placed in position from it. A good location for this line is even with the side adjusting screws of the two end hangers. Then, when all the hangers are placed in position they will align very closely with each other, if adjusted according to this leveled line.

Because of the slight sag in the line, midway between the ends, some allowance must be made on hangers along the sag. The maximum amount of this sag is easily determined by sighting between the end hangers to one placed near the center. The millwrights soon become experienced in allowing for this sag. When a line of hangers is located with the adjusting screws level and in line, that is, horizontally and vertically, the work of aligning the shaft is much simplified in that tightening up the screws evenly will bring the shaft into approximate alignment.

In present-day practice, the sections of the shaft are quite generally connected with compression couplings instead of flange couplings as was the former practice. This change is largely due to the increasing use of ball or other hanger bearings which slip on over the end of the shaft. Taking flanges off and putting them on is a time-consuming and difficult task for a millwright because he seldom has adequate facilities for doing this work on the job. I have never yet seen a compression coupling that was put on right cause any trouble. Whenever a man tightens up one bolt before starting on the others, he may pull the coupling out of line, or it may work loose later. When tightening up a split pulley, or any other piece of equipment, all bolts should be tight-

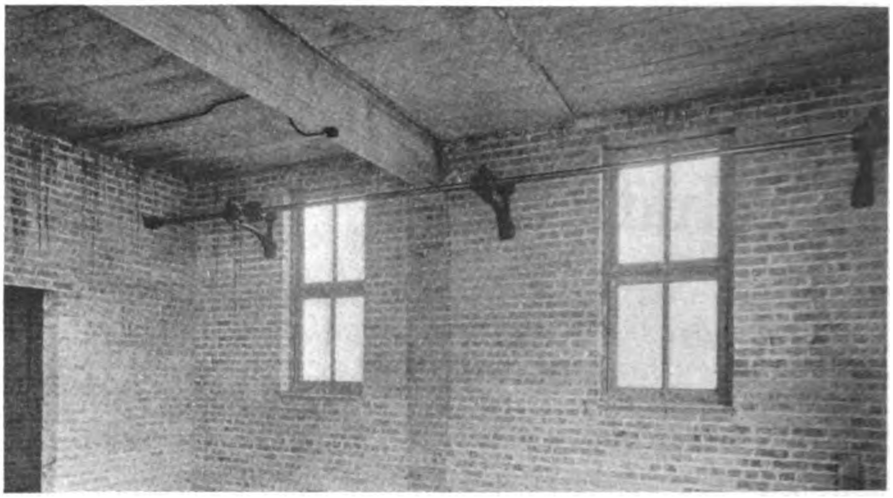


A lineshaft is mounted on both of the two sidewalls.

In this cleaning and dyeing plant, the two 36-ft. lineshafts each pass through two brick walls. The arrangement of the motor is shown in an accompanying illustration. The openings in the wall around the shaft are to be bricked in later. The lineshafts are made up of 20-ft. and 16-ft. sections of $1\frac{15}{16}$-in. shaft, fastened together with a compression coupling. The shafts are supported on 20-in. wall brackets, bolted to the wall. Daggett dumb-bell, self-aligning ball bearings are used in the brackets.

The opposite end of the shaft from the motor drive.

This view was taken in the large room, as shown in the accompanying floor plan. The location of the coupling is shown next to the hanger at the left. This illustration also shows the two walls through which the shaft extends, as well as the opening which it was necessary to cut through the wall for the shaft. This opening is large enough not only for the shaft, but for extending the line for checking the parallel alignment of the shaft.



ened evenly and gradually by working on opposite bolts in sequence and going all the way around before starting over. After the shaft has been in operation a short time, the bolts on all couplings, hangers, and split pulleys should be gone over to see that none have worked loose.

Much time can be saved by handling the bare shafting carefully before erecting. It takes less time and care to prevent bending or scratching a shaft than it does to straighten or smooth the burr afterwards. I believe that industrial plants make a great mistake in turning over the work of delivering the shafting on the job to the lowest grade of labor. I insist always that our millwrights do this, as I believe that the care they exercise saves considerably more time in the alignment. Shafts with flange couplings require especial care in their handling as they are more easily bent.

When flanged shafts or solid pulleys are used, the drop in the hanger must be opened and the shaft section with its attachments lifted into position from the floor. Where split pulleys and compression couplings are used, they are placed in position after the shaft is in the hanger. In such cases, I prefer to have the bare shaft slipped into position through the opening in the hanger frame. Ball and other solid bearings are then slipped on over the end of the shaft. A man will soon learn by experience to see that solid collars and other attachments are in position before the bearings are slipped on. Otherwise, the bearing must be taken off to install them.

I prefer the use of a spirit level and a line stretched parallel to the shaft for leveling and aligning it. Some millwrights advocate stretching a wire above the shaft and measuring down from the wire to the shaft, or putting blocking of predetermined length underneath the wire to hold it up and so eliminate the sag. The amount of sag in the wire is computed mathematically at various distances from each end, for example, every 10 ft. or so, and the millwright makes the allowance for the sag in his measurements. This, I believe, is too complicated for the average millwright.

Another method sometimes used is the so-called water level. This consists of two vessels or gage glasses containing water; the vessels are connected together by a rubber tube of the necessary length. The tube is filled and the water level marked on the outside of the two vessels or gage glasses. Two points on the shaft are level when the water in both gages is at this mark. A rubber tube or hose of sufficient size must be used so that the water will quickly seek its own level. Otherwise, a too hasty reading will give an incorrect indication. Also, a kink or obstruction in the hose line will retard the movement of the water from one glass to the other.

There is still another method of aligning shafts which is sometimes used: that is, by means of a transit and targets. These targets are suspended from the shaft which is leveled up in a manner similar to surveying. The exact method of doing this is too long to explain in detail here. Although I believe that this method would have its advantages on extra long shafts, I have never made use of it because an experienced man can do good work with a hand level and a parallel line. To do this, however, requires considerable experience and a good mechanical sense.

Each section of shaft should be placed in position consecutively. It is well to position, align, and level a shaft as the work progresses instead of going back over it again. Of course, when the job is completed, it must be checked and all adjusting screws tightened. The checking is a simple matter, usually, if the work has been done carefully up to this point.

The alignment of every shaft should be checked about five or six months after it is installed, and every year or two afterwards, depending upon the construction of the building. Buildings sag or shift, the load, machines, or material on the floor above may vary or be moved or screws may loosen due to vibration; any of these will cause a shaft to get out of alignment. In old buildings of not very substantial construction, it is often necessary to set up an alignment which most closely meets the conditions resulting from shifting loads on the upper floors. This is merely a compromise with necessity and is never an ideal situation.

Shafts which go through walls are laid out, erected and aligned in the same manner as any other shafts. The accompanying illustration and the floor plan show a lineshaft passing through two walls. (On one side the third wall is to be built in after the shaft is erected.) This installation is in a cleaning and dyeing plant and special precautions were taken to prevent explosions. For example, the motor and its drive, as shown in an accompanying illustration, are built on a concrete shelf which is to be walled in later so that the only means of access to the motor will be from the outside of the building. In this case the 1$\frac{15}{16}$-in. shafts are supported on 20-in. bracket hangers. Daggett dumb-bell, self-aligning, ball-bearing hanger boxes are used. Each of the two shafts consist of a 20-ft. and a 16-ft. length of shafting joined together by compression couplings.

The bolts holding the brackets extend entirely through the wall and are backed by a short steel plate on

the outside of the wall. Sometimes on thick walls and small shafts, large washers are sufficient. Heavy shafts frequently require sections of channel iron on the outside of the wall to serve as a brace plate to prevent an undue strain on the brickwork. If this is not done, the wall may weaken under excessive loading, particularly at the point where the drive belt is installed.

The layout for the bracket in this case was obtained by leveling from a course of brick. Also, the location of the openings in the cross walls was measured from the sidewalls and the floor. This is a new wall and could be used as a base to give results sufficiently accurate for our purpose.

If the brick courses of the wall were uneven or the walls irregular, a line could have been stretched from one end of the building to the other through the doorway. When this line was leveled, the location of the openings could have been laid out from it. There is usually some place where a line or series of lines can be laid out as a base for any work of this sort. It does not make any difference whether this line is above, below, or on either side, so long as it is accessible at two points near the ends of the shaft, although it is preferable to have it also accessible at other points along the shaft.

Water levels are very frequently used for leveling shafts which go through brick walls. However, I have always found that it is necessary to remove enough bricks to get the shaft through and that sufficient extra space is always available so that a line can be stretched from one length of the shaft to the other through the opening and serve as the basis for the alignment. In all cases, there is sufficient space available to use the level.

After the shaft is aligned, sheet-metal thimbles which have been slipped on the shaft when it was being erected are positioned and the wall bricked in around them. These thimbles have an opening about ¼ in. larger in diameter than the shaft, which leaves a ⅛-in. opening all around between the shaft and thimble. The latter is held in position at the proper distance from the shaft by wedges until after it is bricked in. If properly positioned, the shaft will not rub on the thimble, but the amount of space is so small that there is very little infiltration of gases or fumes from one room to the next. This is an especially important consideration in dyeing and cleaning plants.

When a shaft is erected in a comparatively new concrete building, or in laundries, or other damp locations, it is necessary to grease it well to prevent rusting. This must be repeated occasionally. Also, in a dyeing plant such as this, wooden pulleys are sometimes required because with the wood there is less danger of sparks which might ignite the explosive naphtha or other similar vapors. Also, if steel pulleys are used the belt should be endless, instead of being joined with metal fasteners. At least, these are the requirements in a number of cities. Also, waterproof leather belts are preferable under these as well as all wet or damp conditions.

The problems incidental to checking the alignment of a shaft are very much similar to the original aligning of the shaft. The spirit level and parallel lines are used in the same manner. If it is an old shaft, it is always best to check roughly the level of the two ends and the points between by means of the leveled line by the same method as was used when erecting the hangers. This will show whether the shaft is so far out of level that the position of some of the hangers must be changed because the adjusting screws will not take care of the misalignment. In some cases, it is necessary to insert blocking under the feet of several of the hangers and if this is necessary, the quicker this excessive misalignment is discovered the better. Otherwise, the men may start to align the shaft at one end and find, when near the other end, that a few hangers are so low that the remainder must be blocked up or raised to get them in line. Also, the ceiling in the center of the building is somteimes lower than at the ends, and this pushes the center hangers down. Conditions such as this are quickly discovered by the leveled line, which also indicates the approximate amount that the hangers must be raised or lowered. Where this is beyond the limit of the adjusting screws, blocking is necessary. Where two-point, adjustable hangers are used, all vertical adjustments must be made by blocking under the feet of the hanger. Four-point, adjustable hangers will take care of a certain amount of this vertical misalignment without moving the hangers.

One common cause of trouble with

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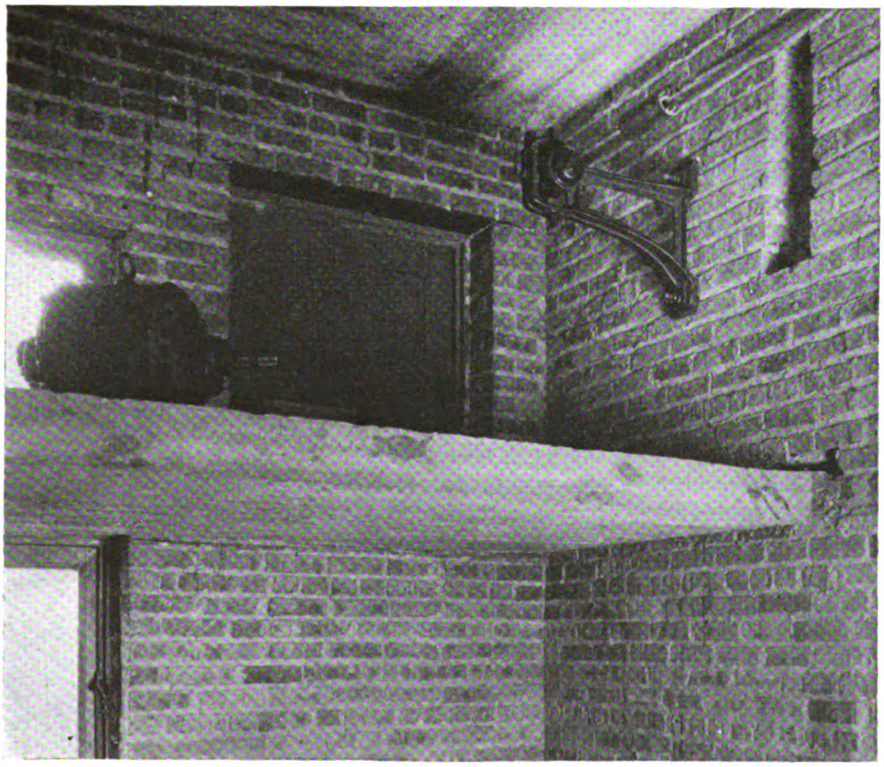
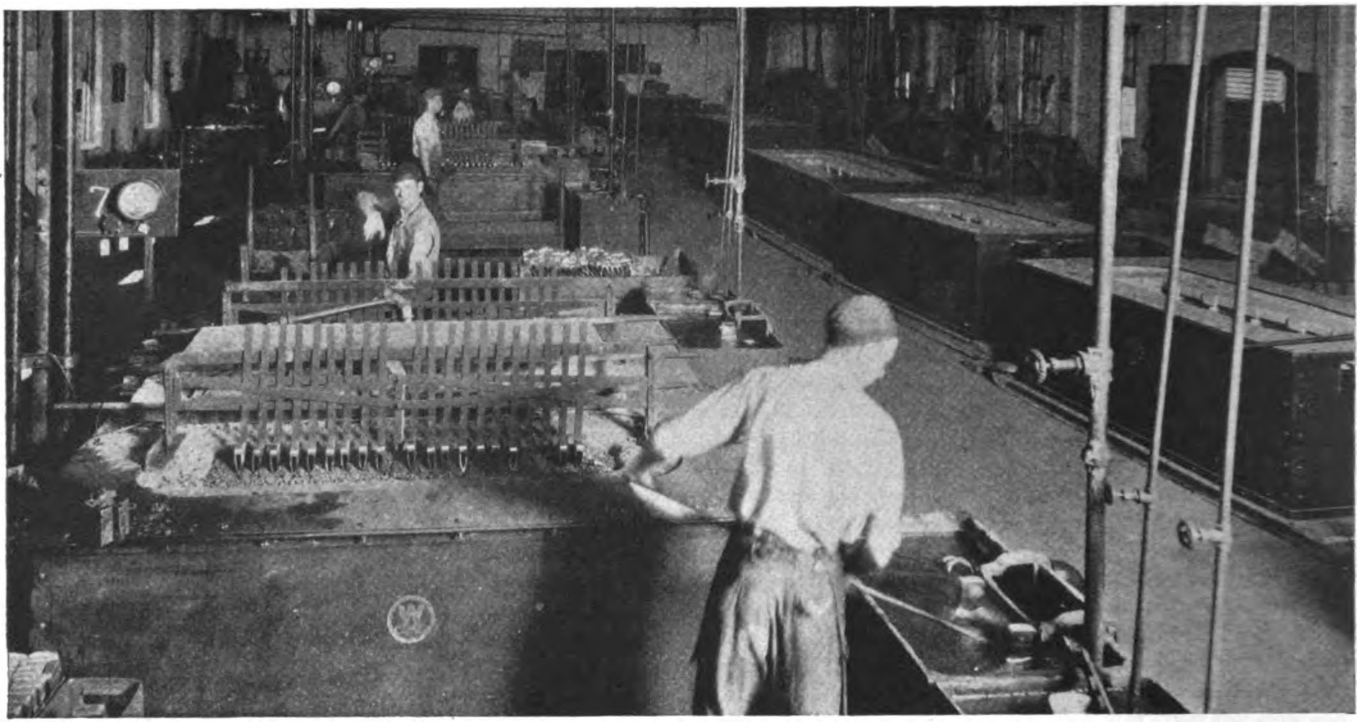


How the motor is enclosed for protection.

The motor is mounted on this concrete-slab shelf and is belted to the lineshaft. When the installation is complete, a wall will be built in along the edge of the shelf and be tied into the main brick wall. The thimble, which will be set in the brick wall, is shown here wedged on the shaft. The only access to this motor room will be through the door at the right. The upper half of the window in that room does not open. The location of the motor control equipment may be seen from the accompanying sketch.



This shows the arrangement of the lead-bath, hardening furnaces in the axe department of a tool manufacturer.

The axes are placed on a special rack which suspends them to the proper depth in the molten lead. When they have reached the desired temperature, they are removed one at a time by hand, quenched, washed in clear water and carried on a truck to the drawing operation, which is essentially the same as the hardening process, but is carried out at a lower temperature. As each axe is removed, another is put in its place. By watching the temperature deviation indicator shown at the left, the operator can time the work so that the temperature will not vary more than 10 deg. A detailed view of one of these furnaces is shown on page 511.

Applications of

Electrically-Heated Bath Furnaces

including a description of types commonly used in heat-treatment of metal parts, with some of the operating advantages which they offer

By CRANSTON H. CARPENTER
Industrial Heating Dept., Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

THE selection of the proper type of furnace for a given heat-treating problem formerly constituted the chief responsibility of the heat-treater. Even before the importance of temperature control had assumed its rightful place in the scheme of the correctly designed furnace, certain results were recognized as being better obtained in one type of furnace than in another. As is often the case, results were obtained before the contributing factors had been analyzed. The furnace engineer has been handicapped until recent years because the heat-treaters, and later the metallurgical engineers did not know what factors were involved in giving the results they desired, nor how to control those factors and obtain the desired results with uniform regularity.

With the increase in knowledge of the principles of metallurgy and crystallography came the better designed furnace and, as a corollary, the better informed furnace engineer. It is impossible to obtain the correct furnace for a given application unless it has received the careful study of an engineer capable of understanding both the process involved and the furnace construction required. Establishment of the fact that the control of heat at the proper temperatures is an important factor in furnace design, drew the attention of the electrical engineer who, in his necessity for economy in the use of power, forced further considerations in furnace design. His necessity proved to be the user's opportunity for it caused the redesign of the fuel-fired furnaces, involving and incorporating in the design the idea of conservation of fuel.

The type of furnace for a given process has been heretofore to a large extent governed by the choice of fuel available in the particular plant desiring the furnace. But today the money value of the B.t.u. applied to the heat-treating problem is known to be of less importance than the ability to produce a given result. Where the cost of heat-treating, when done electrically, is only 0.86 per cent of the selling cost of the finished article, the matter of fuel cost is of relatively little importance. Such costs are obtained in heat-treating certain dies. When the cost of heating assumes 22 per cent of the cost of the manufactured article, as it does in certain vitreous enameling processes, the question of the proper fuel to apply is of more serious consideration, and the selection of the furnace to fit the fuel is more nearly justified than in other types of work.

The bath type of furnace is chosen when the following characteristics are of prime importance:

(1) A non-scaling, non-oxidizing method of heat-treating.

(2) A rapid method of producing a

skin or surface hardness similar to case hardening.

(3) More uniform degree of heating of the work.

(4) Elimination of troubles due to warping and cracking.

(5) To increase the volume of production by more rapid heating.

(6) Greater uniformity of product.

(7) Lower production costs.

The various liquid heat-treating media employed in the heating of steel parts can be divided into two general classes—metals and salts. Lead, and combinations of lead and tin, are the chief metals that can be considered for commercial baths. The salts used for the same purpose usually contain cyanides, chlorides, carbonates, nitrates, and some sulphates, each bath in some cases consisting of a single salt, but often of a combination of several.

The physical characteristics of the medium used are of importance. Without going into details it may be said that of the media mentioned, lead has the highest specific gravity and heat conductivity, with the lowest specific heat and latent heat of fusion.

In comparing the action of molten lead with salt baths, it is noticeable that little or no lead adheres to the work coming out of the bath, to be quenched, if certain precautions are observed. Again, the low latent heat of fusion increases the rate of heating the bath from cold to the liquid state and is an advantage of lead over most of the other liquid baths.

The molten salts, on the other hand, wet the object being heat-treated and adhere to the surface when brought out into the air, immediately solidifying. This characteristic of the salt bath has the advantage of forming a protective film during exposure to the atmosphere, thus preventing oxidation of the surface underneath. It has the disadvantage that the film requires removal, usually by washing. This necessitates frequent replenishing of the salt and increasing the expense of melting.

The bath furnace usually consists of an encasing sheet-iron container, followed by one or more courses of insulating brick faced by a course of firebrick. This firebrick-lined chamber forms the firebox of the furnace and from the upper edge of this firebrick wall the vessel for containing the bath is suspended by means of flanges cast around the top edge of the vessel. Fuel-fired furnaces of modern design have become more complicated than this in an attempt to equalize furnace chamber temperatures. The combustion chamber is separated from the furnace chamber proper and the hot gases, that is, the products of combustion, are led around the outside surface of the vessel containing the bath.

The containers for lead or salt are usually exposed to a highly oxidizing atmosphere on the outside in the fuel-fired type, which often so scales the surface that the vessel warps and cracks. In this type of furnace the manner in which the heat is transferred to the vessel from the burner causes extremely high temperatures at points or spots where the flames or hot gases strike the surface, causing extreme temperature differences and terrific strains in the vessel wall, resulting in distortion and cracks.

In the electric design of bath-type furnace there is a uniformly lower temperature, but a larger quantity of heat is absorbed from almost each square inch of the outer, side surface of the vessel. In contrast, in the fuel-fired type of furnace the flame or hot gases are admitted at the bottom in a tangential direction, producing a whirling flame. Various schemes of recirculation have been used in an attempt to avoid extreme temperature concentrations at any one point.

Reversal of the direction of flame or hot gases at the top has not improved conditions since both methods of firing produce zones of marked temperature differences between the top and bottom of the vessel, which result in stresses and vessel straining.

In the electrical design a nice arrangement of heating elements permits proper and equal temperature distribution with, when necessary, a slight concentration of heating elements at the inside top of the heating chamber to compensate for radiation and convection losses across the top of the bath.

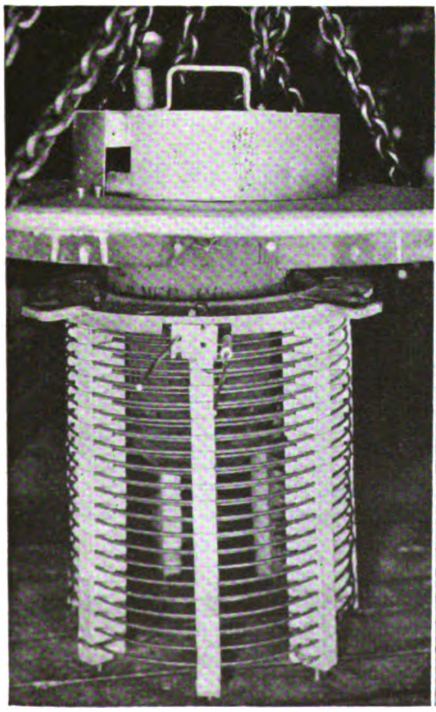
In the case of the electric furnace the resistors in the better designed types are suspended from the inside walls of the heating chamber and when necessary are laid on the bottom. The bottom in addition, is usually provided with a drain from which the contents of the pot will run off to the outside in case the vessel leaks or cracks.

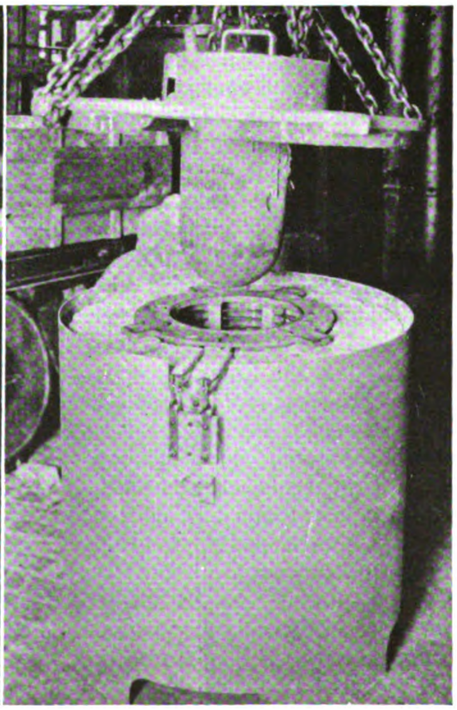
The shape of the vessel depends upon the character of the work. Either cylindrically-shaped vessels with round bottoms, or rectangular vessels with ellipsoidal bottoms, are used. The success or failure of a bath furnace often depends upon the correct design of the sidewalls and bottom of the vessels.

Two examples of standard, electrically-heated bath furnaces are shown in the accompanying illustrations. The bath furnace shown on this page operates at a temperature

This cylindrical-type bath furnace is employed to harden and temper drills.

The view at the left shows the heating element surrounding the vessel. The complete furnace with the vessel and top raised is shown at the right.





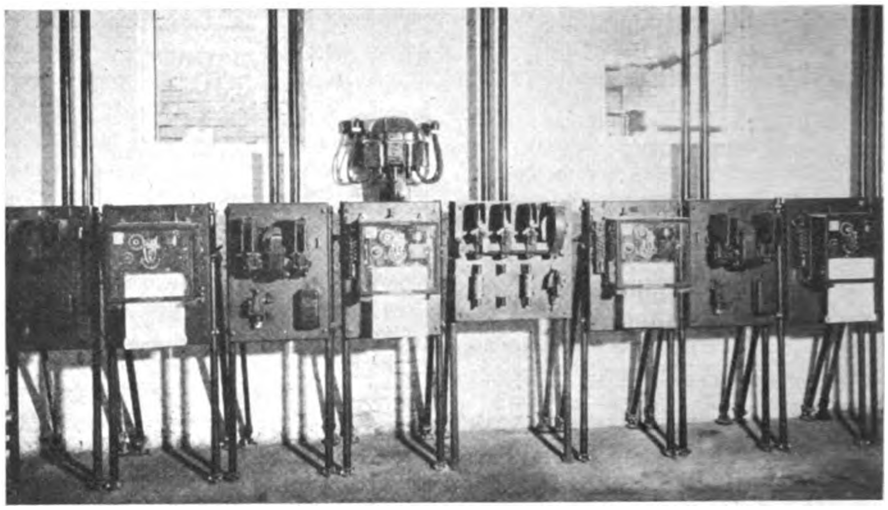
of about 1,500 deg. F. It is of the cylindrical type, the vessel being 10 in. in diameter and 17 in. deep. This furnace is used to harden and draw drills in a large manufacturing company where it is necessary to prevent these drills from distorting both during the heating up to the hardening temperature and during the subsequent quenching.

A bath furnace of similar design, but employed to heat 350 lb. of cyanide has been in operation in the heat-treating department of a large electric manufacturing company for several years, and another one of the same type is now employed in the heat-treating processes of one of the well-known watch manufacturers.

When considering furnaces of the lead-bath type in general, a comparison of fuel costs is secondary to the results to be desired. A comparison on the fuel basis is very misleading, but it may be stated that, in general, electric energy at 2 cents per kilowatt-hour is competitive with city gas at 50 cents per thousand cubic feet and oil at 6 cents per gallon. These figures are comparative and take into consideration the source of power plus the economical advantages resulting from the use of electric power for heat. The data are based on 550 B.t.u. gas and 13,500 B.t.u. oil

If we compare artificial gas with 550 B.t.u. per cubic foot, natural gas with 957 B.t.u. per cubic foot, and oil with 13,500 B.t.u. per gallon, with electric energy at 2 cents per kilowatt-hour at the proper furnace efficiency for bath-type furnaces operating with the various fuels, we find the following interesting development of the above economies.

The coal-fired furnaces are not considered in this discussion because of their low efficiency and obsolescence for refined heating processes. It is doubtful if either the gas-fired furnace or oil-fired furnace ever reaches above 20 per cent thermal efficiency in bath-furnace applications, while with the electric furnace of this type the thermal efficiency is 75 per cent. Thermal efficiency of any furnace has little significance or importance for it may require only 25 kw. per hour to maintain an electric furnace at temperature, whereas the furnace may be rated 100 kw. and 75 kw. may be actually absorbed in the work. Following this thought out, in the case of fuel-fired furnaces it may require 85,300 B.t.u. to maintain the furnace at temperature while idling, but if it is desired to put four



Automatic control equipment for bath furnaces shown on page 508.
The furnaces are individually controlled by means of a recording pyrometer, which actuates a contactor panel.

times this many B.t.u. into the stock being heated, it will require more than 341,200 B.t.u., because in order to get that many B.t.u. into the work it will require that 1,706,000 B.t.u. of fuel be consumed if the bath receives only 20 per cent of the actual heat in the fuel.

However, in selecting the electrical type of bath furnace advantage is taken of the highest "over-all economy" and "form value" with its perfect heat generation, desired heat distribution and automatic temperature control in almost ideal perfection.

An example of such a selection is seen in the case of a large axe manufacturer whose plant is located in a natural gas field. In this case, it is interesting to note that natural gas costs 18 cents per thousand cubic feet and electric energy about 1 cent per kilowatt-hour. This factory has a large production of axes of all sizes, grades and weights as well as high-grade small tools, such as claw hammers, lather's hatchets of various descriptions, fireman's axes, machinists' hammers and so on, all requiring scientific temperature control in the final heat-treating process preliminary to the finishing and polishing operations. In this factory there is a connected load of 1,156 kw. distributed among 17 lead baths for hardening tools at about 1,400 to 1,500 deg. F., and six lead baths of exactly similar design for tempering between 600 and 700 deg. F.

This type of furnace is illustrated on page 511 which shows a complete furnace with the lead-containing vessel elevated from the heating chamber. The top protecting castings are placed at the side. Each of these furnaces is controlled automatically by means of a recording pyrometer which actuates a suitable contactor panel. This equipment is centralized and located in separate control rooms. One side of one of these control rooms is shown above.

The handling operations are entirely manual and the furnaces are supplied with a special rack by means of which a definite number of parts are properly suspended in the lead.

The cycle of operations includes removal of the parts from the lead, quenching, washing in clean water, and placing on a truck to be carried to the next operation, which is the drawing operation and is essentially a repetition of this cycle at a lower temperature. An untreated tool is then placed on the hook of the rack that has just been vacated. The cycle is repeated and a temperature deviation indicator located above the furnace in the line of sight of the operator, provides him with an indication of the variation of temperature from the desired or correct one for operating.

By properly timing his efforts the operator keeps the temperature variation within 10 deg. When he is working too fast, the temperature falls and when working too slow the temperature rises. Enforcing the maintenance of the proper temperature automatically enforces a correct heat cycle and a definite production. The illustration at the beginning of this article gives a clear conception of the arrangement of the apparatus and how it is operated.

On the basis of full production, 14 men are required to handle a somewhat larger production than was formerly handled by 39 men in the superseded gas-fired equipment. In addition to this, it no longer requires

a skilled operator to harden the tools properly. With the recording, controlling pyrometer set at the desired temperature and leaving a record, and the deviation indicator above the bath, a common laborer can quickly get the swing of the correct operation and if the recorder chart shows overheating or underheating, it is a report of the manner in which the tools have been handled.

Also, the correct number of pieces per operator per shift can be assigned to each operator and a definite amount of correctly heat-treated tools will be returned at the end of the shift. This is an advantage to the operator who, in turn, knows how he will have to operate to get the required number of pieces per shift; his responsibility consists in keeping the needle of the deviation indicator at the zero position.

With such an equipment properly operated, the tool acts as a check of the previous manufacturer's operations up to this time. With absolute control of the heat-treating factors, the heat-treater is eliminated from an investigation to account for an imperfect tool and it then becomes a matter of adjusting or correcting some previous manufacturing procedure. Since the installation of the electric equipment, the rejection of tools that would not pass inspection before going to the store room has been cut down from 15 to 20 per cent to practically nothing. The cost of production has gone down, the capacity of the whole shop has increased, and the working conditions in the heat-treating departments have been very much improved. In addition the life of the vessel has been increased from a few weeks or months to over 15 months by continuous operation, with no failures and no loss of lead except that consumed in the process.

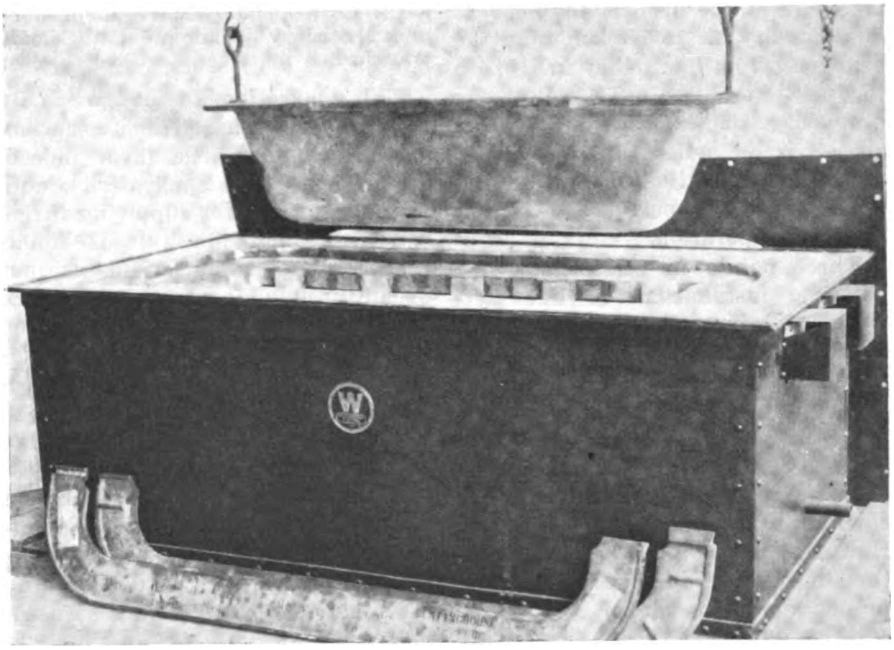
From the hardening furnaces in the axe and tool room, the tool goes to a drawing furnace of exactly similar dimensions, but of less installed electric capacity, where the cycle of operation is exactly similar, except the temperature is the lower one required for proper drawing.

The lead bath during the operating period is covered with about 1 in. of granulated coke to reduce radiation losses. During idling periods, such as overnight shutdowns, an insulated cover made of structural steel and Silocel bricks is used to cover the pot.

An interesting sidelight was obtained in testing a shipment of 1,300 tons of high-carbon steel. In quantity production where axes are made at the rate they are in this factory, steel is carefully inspected, one of the methods employed being the practical test of putting it through the operations it must undergo when made up into the finished article. Of the shipment referred to, test pieces sufficiently long to allow testing one end in the fuel-fired furnace and the other end in the electrically-operated furnace were selected. The best grade of operators, with long years of experience back of them, were selected for the fuel-fired test. The results obtained from the old, fuel-fired furnaces gave a sufficient number of unacceptable test pieces to have caused rejection of the shipment in the old days, but under the electric furnace test, each one of the test pieces proved the steel to be of a grade that would make excellent axes. On the result of this test a 1,300-ton shipment of expensive, high-grade steel was accepted.

Here is another type of bath furnace, with the vessel removed from the heating chamber.

This furnace is of the same type as those illustrated in the headpiece on page 508. It is rated at 62 kw., 220 volts, 1,650 deg. F.



Another lead bath installation of interest is in the plant of a large wire rope manufacturer. Here lead baths are being used for the hardening, quenching and drawing of carbon steel wire. Vessels of exactly similar design to those at the axe factory are in use and the wire is passed continuously through the baths of lead, held at the correct temperature. Some of these lead baths have been in continuous operation for two years without any vessel failures. Automatic temperature control is obtained in the present equipment in a manner similar to that described above.

The present trend of development is toward a further electrification of wire hardening, quenching and drawing, all in electrically-heated lead baths. Also, in this connection, the trend of development in control is for closer temperature regulation to take care of the variables introduced by the varying sizes of wire and the different speeds of operation.

These vessels are run in tandem, the high-temperature bath, the quenching bath, and the drawing bath being in a straight line. The bundles of wire, either round wire or flat wire, in some cases 5 in. wide, are passed through a high-temperature lead bath, then into a lead bath held just above the melting point of the lead, then up through reels in the air and after a certain travel again into the draw-back lead bath held at the proper temperature for drawing the wire, which is being pulled through these baths by the draw-out reels situated beyond the last draw bath.

Several installations of this type have been made and in order to obtain the proper temperature control, the electric input into the different units, to correspond to a given temperature, is obtained by the use of contactors actuated by pyrometers. This control, however, could be obtained by voltage regulators gov-

erned by controlling pyrometers. This latter type of control will give very close temperature regulation by varying the energy input into the bath.

This method, in addition to giving closer temperature control than can be obtained by other known means, has another valuable characteristic: namely, the power demand is continuous and is varied only to correspond to the actual requirements. Thus it does away with the "on and off" the line feature, with the consequent irregular demands on the power plant. This regulation of input also prevents over-storage and depletion of heat storage in the walls of the furnace, as was the case under the old method, and hence eliminates the "over-shooting" and "undershooting" of temperature frequently found in the present types of temperature control which do not supply some current at all times.

The surprising features of this type of electrical apparatus, and of the installations cited, are the high economies that have been obtained: careful studies have been made of these economies, but space and occasion do not permit a tabulation of them. Those in contact with these developments have found such improved values of thermal efficiency and increased value of products obtained by the use of the electrically-controlled metal bath that they are in position to understand and forecast the over-all economies to be expected in a proposed lead bath electrification.

Erecting a Lineshaft Drive

(Continued from page 507)

shafting results from placing the hangers too far apart. Ordinary spacing for hangers is 8 ft. However, a drive pulley should either be placed near a hanger, or an additional hanger installed to take care of the side pull. Also, where a large number of pulleys are grouped closely together, the addition of a hanger in the center of the group will give the desired rigidity.

It should be remembered that high-speed shafts require closer spacing of hangers unless an extra oversized shaft is used. Adding extra hangers is one method of overcoming excessive vibration which may result when the shaft of an old installation is speeded up. Generally, in connection with an old lineshaft installation, it is necessary to add a hanger only in a few places where a number of pulleys are placed or an extra heavy pull, is taken off, at some distance from a hanger.

When cutoff couplings are used in a line of shafting, special care is required in aligning and supporting the shaft because any working of the ends of the shafts within the sleeve would soon cause trouble for the clutch. Hangers should be placed on both sides of cutoff couplings to support them.

We are seldom called upon to install mule stands now. Generally a plant will make two separate sets of lineshafts out of an installation, each with a separate drive, instead of trying to connect them together at an angle by means of a mule stand which were formerly rather widely employed for this purpose.

Frequently we are called upon to replace pulleys on a mule stand with ball-bearing loose pulleys. This eliminates the difficulty incidental to the lubrication of mule stand pulleys because the shaft is vertical and the lubricant runs out at the lower end and is thrown off by the high speed of the shaft. Ball-bearing pulleys retain the lubricant and to that extent, at least, remove one of the present objections to the use of mule stands.

Many operators believe that the two shafts to be connected by a mule stand must be absolutely at the same level and at right angles to each other. This is not the case. However, if the two shafts are not at the same level, it is necessary to mount the mule stand at an angle to take care of the drop in the belt. It is necessary to remember that the belt goes from one pulley and on to the next in a line. To obtain the proper location of the pulleys and angle of the mule shaft sometimes requires some adjusting before the installation is properly lined up and ready for operation.

Three points in connection with handling installations of lineshafting are so important that they are worth emphasizing, in conclusion. In aligning a shaft the millwright must get it not only *level* but *straight*. Also, any efforts exerted toward placing the hangers in the proper position reduce the work incidental to the aligning afterward. However, without a proper foundation or support for the hanger the proper alignment cannot be successfully maintained.

Connections for Transformers

(Continued from page 504)

The other connection using only two transformers for a three-phase transformation, is known as the T-T connection and is shown in Fig. 6. A special 86.6 per cent tap is required on the teaser transformer as is shown.

Advantages — (1) Winding characteristics and voltage stresses are practically the same for this connection as is the case with the star-star connection.

(2) For initially supplying a load which will ultimately be greater, two interchangeable transformers with suitable taps may be installed to facilitate an ultimate changeover to the delta-delta connection. There would be the same initial saving in cost as with the open-delta connection.

(3) Third harmonic voltages and currents are usually very small and of no practical importance.

(4) If desired, three-phase, two-phase, and single-phase loads may be supplied simultaneously.

(5) The neutral points are available for grounding or loading purposes. For the latter purpose it becomes more important that the halves of the main transformer windings should be interlaced.

(6) The iron loss of the bank will be slightly less than with the open-delta connection, due to the lower voltage, that is 86.6 per cent across the teaser transformer.

Disadvantages — The disadvantages of this type of transformer connection are:

(1) While only two single-phase transformers need to be installed, their total rated kva. must be 15½ per cent greater if the transformers are interchangeable (or 7¾ per cent greater if non-interchangeable) than the actual load supplied.

(2) Corresponding halves of primary and secondary windings of the main transformer must be interlaced.

This connection, for use primarily to give a three-phase transformation, has found very little favor indeed. Theoretically, its application would be most suitable for supplying three- two- and single-phase loads simultaneously, but as such loads are not usually found together in modern practice, the connection has been very little adopted. It has the advantage over the open-delta connection in that the primary and secondary neutral points are always available.

A discussion of parallel operation of transformers, losses, voltage regulation, and power factor, as well as sample computations for determining the same will be given in a succeeding issue.

THIS IS the sixth article of a series on lubrication. In the first article, which appeared in the December, 1925, issue, the use of oils and greases in industrial lubrication was discussed. The second article, in the March, 1926, issue, explained the terms used in the specification of lubricants. Other articles have covered: equipment for applying lubricants, May; lubricating motor bearings, July; and, lubrication of hoists and traveling cranes, September. This article will discuss lubrication of conveyors.

Some practical

Problems in Lubricating Conveyors

with methods of solving them employed on types of equipment commonly used in industrial service

Lubricating the troughing rolls of a belt conveyor.

Here a portable horizontal-type, high-pressure Alemite compressor with a slip-on coupling is used. The industrial-type fittings are placed on the end of the hub of the troughing roll and the lubricant supplied to all bearings through the single opening. The attendant must be sure that an ample quantity of lubricant is applied under sufficient pressure to supply the inaccessible bearings on the opposite end of the rolls. The rolls are preferably lubricated while the conveyor is in motion. The fitting for the return roll may be seen just below the operator's left elbow.

By FRANK E. GOODING
Associate Editor, Industrial Engineer

EQUIPMENT used for handling materials, as stated in the preceding article of this series in the September issue of INDUSTRIAL ENGINEER, is frequently subjected to neglect, particularly from the standpoint of lubrication. However, the importance of suitable lubrication to the proper performance of machinery of all kinds as well as to its upkeep, particularly with relation to reduction in wear and tear and the minimizing of the expense of repair, is so well known to all who are acquainted with factory equipment that it would seem that the question of providing suitable lubrication of the conveying and elevating equipment would need no special emphasis. In spite of this, as has been demonstrated by the extensive experiences of manufacturers of this equipment, industrial operating engineers and maintenance superintendents frequently overlook the necessity of reasonable attention to the lubrication of the moving parts of conveyors and elevating equipment. Experience has shown that nearly all the trouble to which this class of equipment is subjected may be traced either directly or indirectly to incorrect or insufficient lubrication.

Conveyors are of three general types; gravity, belt, or chain. Each of these types, particularly chain conveyors, is manufactured in a variety of forms or modifications to meet special purposes. The lubrication problems differ with each type, and also with the purpose for which the conveyor is used. Probably the most attention to lubrication has been given to belt and gravity conveyors, although new installations of chain conveyors have better provisions for lubrication than the older types.

Conveying and elevating machinery, moreover, has certain requirements which cannot be met by the ordinary methods of oiling applicable to most other types of machines. In the first place, the number of bearings and surfaces which must be lubricated is much greater than it is in the case of almost any other type of industrial machinery. A production machine in a factory is fairly complicated if it has 20 bearings to be kept oiled. It is not unusual for a conveyor to have 200 bearings, and not be a particularly long one. Unless, therefore, time is a secondary object, which is seldom the case, the lubrication system should be so designed that each bearing can be dealt with quickly and conveniently.

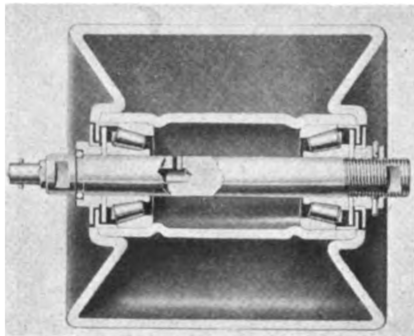
Because of the large number of bearings in a conveyor line, comparatively large savings result from the use of improved anti-friction bearings. In an actual installation, savings of 35 per cent of the power required to drive the conveyor have resulted through installing anti-friction bearings with grease, pressure lubrication. A large proportion of the conveyors installed at the

present time are provided with some kind of anti-friction bearing, not only to reduce the friction load, but also to take advantage of the better facilities for lubrication which such bearings offer.

Perhaps the tendency to slight lubrication is in part brought about by the knowledge that the speed of operation of conveyors and the resulting speed of bearings is small in comparison with the many high-speed machines which comprise the usual factory equipment. This comparatively slow speed of operation of conveyor parts justifies a certain purposeful elimination of the necessity of lubricating bearings on the part of the manufacturer of conveying equipment as well as on the part of the user. For instance, one of the commonly employed types of gravity roller conveyor for handling package loads is designed so that the rolls of the conveyor turn in ball bearings.

It will be appreciated that under normal use, the rolls of a gravity roller conveyor are only turning while loads are passing over them. In the aggregate, even when conveyors are in constant use, the amount of time in which the rollers of a gravity roller conveyor are idle is considerable and even when they are turning they do so at slow speed. Therefore, if the ball bearings of a gravity conveyor are properly designed and sufficient care is exercised in their manufacture to make sure that the ball races are smooth and that the bearing is assembled in a manner to give easy turning performance, the bearings are not likely to need lubrication when operating under normal conditions. However, the balls and races need some lubricant to prevent oxidation of the surfaces.

Various conditions of use of gravity roller conveyors, however, make necessary special designs of gravity roll bearings in which careful consideration is given to lubrication. By way of illustration, certain applications of gravity roller conveyors cause them to be placed in locations where the air contains a large amount of grit, dirt or other pulverized substance. Gravity roller conveyors which are to be used in a foundry must be so designed that the bearings are protected from grit.



Another method of lubricating a pressed-steel troughing idler pulley.

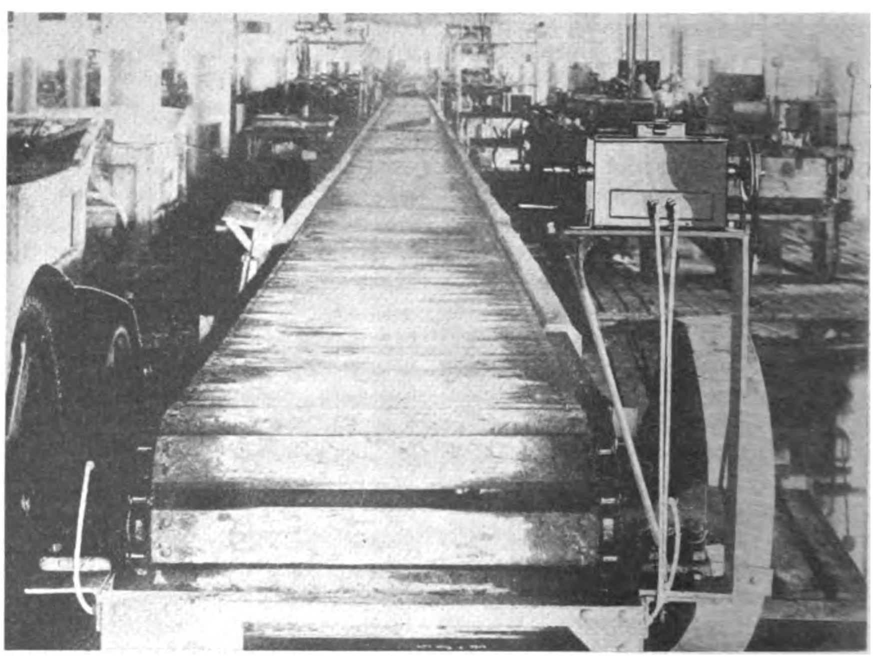
In this new Stearns idler pulley the lubricant is forced in through a pressure fitting at the ends of the shaft and enters the chamber at the center. From here the lubricant is distributed to the Timken roller bearings in the hubs at each end of the idler pulley.

Conveying and elevating equipment is seldom readily accessible. In many cases it runs through narrow tunnels, between buildings, through floors, or at some distance above the ground level. It is, therefore, strongly advisable that whatever lubricating system is adopted it should be such that once attended to it will not require further looking after for a considerable length of time. Every industrial man is well aware that bearings which are hard to get at are likely to receive far less attention than do others that are more easily accessible, irrespective of which requires the most attention. To meet these conditions, many manufacturers of conveying equipment recommend the high-pressure system of grease lubrication which has been adopted quite largely by the manufacturers of automobiles, to meet a similar demand for quick and easy servicing, even in parts difficult of access and by the unskilled or inexperienced owner.

Another reason why high-pressure grease lubrication, instead of oil is usually preferred for belt conveyor bearings is that high-grade, anti-friction bearings are not commonly used on conveyors and elevating equipment and so the mechanical fit of the bearing is not always tight enough to retain an oil lubricant.

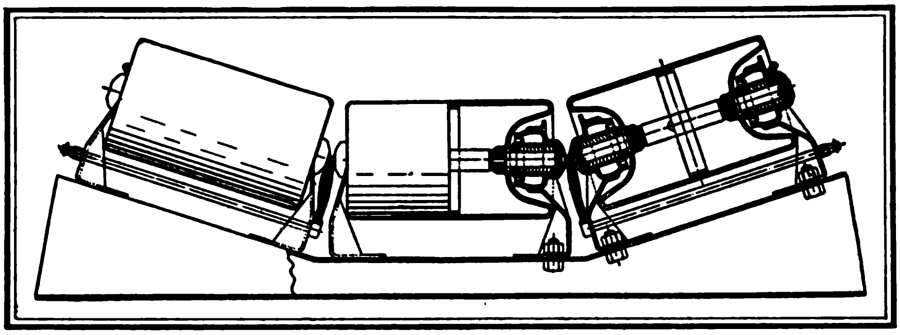
Still another point in favor of the high-pressure system of lubrication is that conditions seldom are such that a conveyor or elevator can be shut down during working hours. Conveyors generally form an important link in the production system and, although temporary shutdowns of production machines are often possible if it is necessary to replace a part, or for minor repairs or oiling, it is generally true that to shut down the conveying system even for a few minutes ties up the entire department which it serves and often the entire plant. For this and the other reasons mentioned it is essential that a method of lubrication be provided with a sufficient lubricant reservoir to permit the bearings to run for a considerable time, for months if necessary, without attention.

Similarly, conveyors that are placed in flour mills or in other types of industries where pulverized material is present in the air must be so protected that no foreign material will enter the bearings and



Force-feed lubricators on bearings of driving head and chains of conveyor.

The roller chains to which the slats in the conveyor are fastened are lubricated by a McCord (McCord Radiator and Manufacturing Co., Detroit, Mich.) force-feed lubricator which forces oil through tubes to brushes attached to the frame. The chains are lubricated as they travel through the brushes.



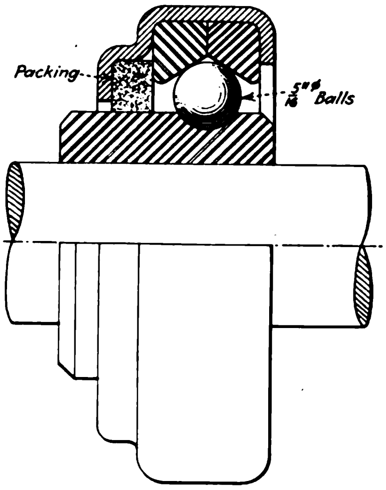
Both sides of this conveyor must be accessible for lubricating.

However, if only one side were accessible all the Alemite connections could be extended to that side. It is noticeable that no single connection is made to more than two bearings. In this instance a three-pulley idler conveyor is equipped with Hyatt roller bearings which are lubricated by the pressure system. Two pieces of flexible hose from the pipe extending underneath the roll carry the lubricant to the bearings at the center of the conveyor.

cause them to operate inefficiently. With this necessity in mind, special-duty, gravity roller bearings have been so designed that the balls are protected from grit by the use of tight-fitting felt washers housed in an enclosed unit bearing.

Similar considerations must enter into the design of all types of conveyors which are to operate in a dusty atmosphere. It is safe to state that in the application of conveyors to foundry and similar work, special attention must be given to the lubrication of all belt idler and pulley bearings. Conveyor rolls have been developed for such specific purposes, wherein all bearings are equipped with lubricating fittings of the ball-and-spring type, such as the Alemite, Zerk, or Dot. It will be appreciated, therefore, that there are certain applications of conveyors which make the subject of lubrication of so great importance as to make necessary the employment of fittings designed in a manner to bring about the greatest efficiency in lubrication.

Where ore, coal, ashes, cement or other abrasive materials are handled, lubricant applied under pressure will form a seal at the ends of the idler-roll hubs. Repeated applications keep forcing the used lubricant out, which takes with it the dust that settles at the bearing hub. In dangerous locations or places difficult of access the oiler need not get closer to moving parts than the end of the fitting provided for portable hand-pressure guns. Also, fittings for pressure lubrication can be placed where there is less likelihood of their being knocked off by falling material than is the case with grease cups. In some cases, as on the coal carriers shown in an accompanying illustration, flush fittings are used.



Cross-section of heavy-duty, gravity ball-bearing conveyor roll.

The packing prevents the escape of the lubricant on the outside and the bearing fits into the end of the roller. The bearing is made to exclude dust and moisture and the lubricant prevents oxidation of the balls and races. This Lamson Company (Syracuse, N. Y.) bearing is designed to handle 300-lb. loads at 50 r.p.m. on gravity conveyors.

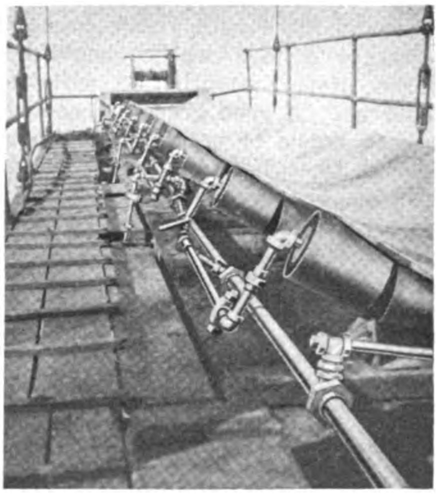
On some conveyors the grease cups are made of cast iron instead of pressed steel. In such cases the cast-iron cups act as a collar on the end of the idler roll shaft and are slipped over the end and fastened with setscrews. Under these conditions, the pressure fitting is attached in the center of the cup.

Pressure lubrication fittings are also used very commonly to lubricate the inside rolls of a troughing idler on a belt conveyor. The fitting may be extended out to the side where the lubricant can be forced in without danger to the oiler. Also, where the conveyor is placed close to a wall the angular fittings with pipe extensions are run up over the conveyor, or underneath, and the lubricant applied from one side.

The Keystone pressure system is also applied to conveyors, as is shown in an accompanying illustration. One such installation on a loading tower and conveyor consists of one 4-lb. lubricator taking care of a total of 172 bearings on the turntable and conveyor. The piping is arranged for a three-way outlet, one to the conveyor and the other two to points in the control house. By means of the three-way outlet approximately one-third of the bearings are lubricated at a time. The three-way valve is then turned, another section lubricated, and so on. In this way one unit can serve a large number of bearings. The farthest bearing reached is 90 ft. away. On the trolley which operates the clam-shell bucket, the eight sheave wheel bearings are connected to one 1-lb. lubricator.

Belt conveyor idler roll bearings of the type which causes the belt roller shaft to turn in a bronze bearing are often designed with an oil hole and a wick and it is proper to emphasize that unless belt idlers are turning in ball bearings or in some type of bearing which is designed so as not to require lubrication, much more care should be given to the oiling of the bearing through the oil hole provided for the purpose than it usually receives. Belt conveyor idler bearings of this type should normally be gone over with an oil can at least once a week.

Inspection of any belt conveyor which has not received proper lubrication attention will show a considerable number of idlers which are not properly turning because they have become clogged and inactive. While such lack of proper performance of all parts of a belt conveyor may not be as detrimental a matter



Application of Keystone fittings to a belt conveyor.

Grease is forced by a compression gun through the header into the various bearing heads. In such cases the compression unit is generally placed near the center of the conveyor line and by manipulating two-way valves, the pressure is first applied at one end and then by turning the valve, at the other.

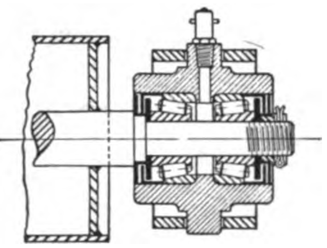
as the lack of proper performance of a part of some high-speed machine, it is nevertheless, obvious that full efficiency is not obtained.

It may be that the inability of a roll to turn may cause loads in transit to stick or become jammed in such a manner as to cause damage to them, or it may be that the bearings and rolls which have not been given proper attention will have to be renewed. It is evident that wear and tear on the belt of a belt conveyor, will result when it is dragging over idlers which are not turning properly because of inadequate lubrication.

The return system of a conveyor belt does not, as a rule receive the attention to its lubrication which it deserves. It is easily seen, however, that since the only part of the belt which is useful is that part actually used for handling the material, and because the friction losses are practically independent of that useful load, the return system is as fully important as the load carrying portion.

It is sometimes necessary to make repairs to conveyors. Many of the modern types of conveyors have provisions for removing the bearings and a small stock of extra bearings should always be carried on hand. Frequently, with gravity rollers, however, it is easier and quicker to remove the entire roller. Chain conveyors require special provisions for replacements.

Take-up and drive pulley bearings of belt conveyors, sprockets of chain conveyors and similar apparatus are normally fitted with grease cups or pressure fittings which should be given proper attention at suitable intervals. A good grade of bearing grease should be used and the cups should be turned or the pressure gun applied frequently enough to supply suitable lubrication. The drives of conveyors which employ gears should be given proper attention by using a suitable gear grease; driving gears are frequently neglected. Where speed reducers are



The bearing of a return roll.

Here a pair of Timken roller bearings are placed at each end of the conveyor return roll and lubrication is provided through a high-pressure fitting. This roll is manufactured by the Stearns Conveyor Co., Cleveland, Ohio.

used the oil reservoir should be emptied and refilled at intervals.

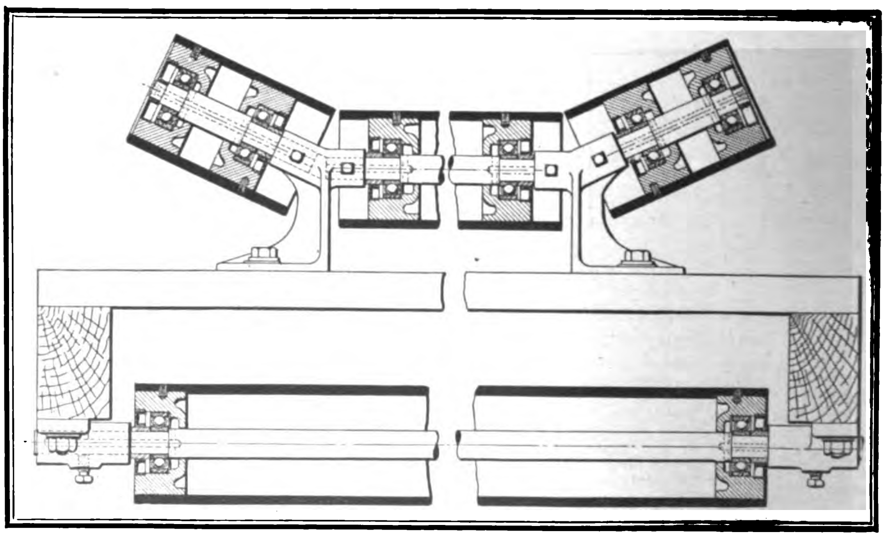
For some types of work, roller bearings are employed in conveyors and suitable housings with the proper fittings are provided. Conveyors with tapered roller bearings, one at each end, with proper provision for lubrication are also used.

A type of conveyor frequently employed for handling package loads is constructed with slats attached to roller chains. Another type of conveyor for a somewhat similar purpose is a form of chain conveyor wherein the load travels on moving chains. Also, certain types of inclined and vertical elevating conveyors for package loads employ moving chains. There is a very noticeable tendency on the part of maintenance men to overlook the importance of keeping these chains clean and lubricated properly. A mixture of oil and graphite is well suited for this purpose and all moving parts of such a chain should be kept well lubricated. It is often advisable to place a lubricating mixture along the angle-iron or channel runways of chains.

Care must be exercised by the attendants where all the idler pulleys on a carrier frame, as on the troughing rolls of a belt conveyor, are lubricated through a single feed pipe to see that the grease reservoir is filled at each pulley. Sometimes in such cases the attendant stops when the reservoirs of the first two or three bearings are filled and does not supply enough lubricant or apply sufficient pressure to reach the bearings at the opposite end. Supplying separate pressure feed nipples for each pulley, or for each pair of adjacent bearings overcomes this.

Certain special uses of conveyors make necessary the employment of special-temperature oils. A conveyor in the freezing room of an ice-cream plant or power-driven conveyors in cold-storage rooms and similar places make necessary the employment of low-temperature oils. Conveyors that operate under comparatively high temperatures may require special types of lubrication. Again, it is often necessary to employ conveyors in ovens and similar places where the temperatures are so high that the conveyor must be designed to function practically without lubrication.

The choice of a grease lubricant is very important. For most ordinary purposes a good grade of semi-liquid lubricant of about the consistency of vaseline is satisfactory. Bearings which are exposed to excessive cold or moisture, usually require special compounds. A semi-liquid lubricant, for example, would leak out of the reservoir if exposed to heat much above 100 deg. F. For such conditions, or any other unusual service problem, it is well to consult with a manufacturer of lubricants to get his advice and suggestions. In excessively hot locations in which the temperature rises higher than the melting point of the grease com-



Lubrication of ball-bearing, troughing idler roll for a belt conveyor.

This type of mounting and method of lubrication are recommended by the New Departure Manufacturing Company for conveyor units. Here the three bearings at each side are lubricated through openings in the center of the shaft from the two outside ends. A lubricant is forced in by the pressure system, using a semi-fluid oil or light grease, which may be applied while the conveyor is in motion, as the revolving bearings tend to aid the entrance and distribution of the lubricant.

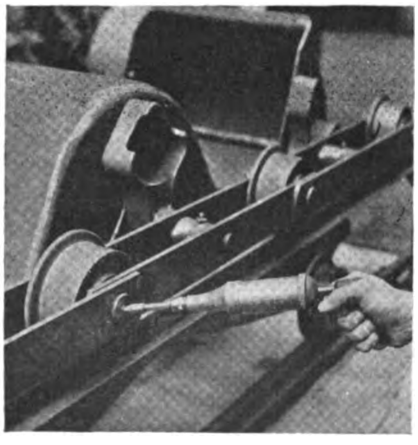
pound, it is often necessary to adopt grease impregnated with graphite as a lubricant and sometimes to use especially designed bearings.

Bearings on conveyors subjected to acids or moisture offer a special problem. For example, gravity roll conveyors used in milk bottling plants must be flushed with hot water. For this service one manufacturer uses a special sleeve bearing and shaft made of a non-corrosive alloy. No attempt is made to lubricate the bearings.

In the case of light-duty conveyors there are many installations where even the occasional dripping of oil would be seriously objectionable. Conveyors which are installed along ceilings above delicate or perishable merchandise or other products must either be fully protected on the underside against any possible dripping of oil, or bearings which do not require oiling must be used. An excellent example of this is found in department stores where the belt conveyors pass along the ceiling over counters filled with delicate merchandise. On such conveyors impregnated oilless wood bearings are often employed, so as to eliminate any trouble from oil dripping.

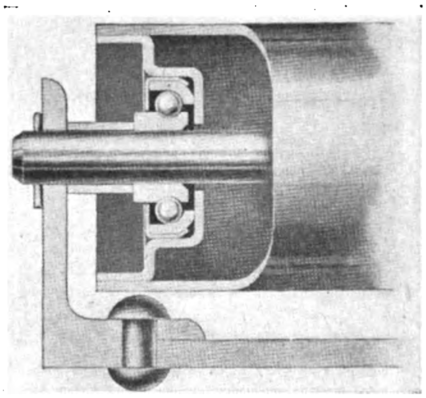
From the foregoing it is evident that each application of conveyors must be determined upon after a definite understanding has been obtained of all the requirements. The question of lubrication is not alone one of design, but it is also a question of the use which is to be made of the conveyors, and the place where they are to be installed.

Operating executives will do well



Flush fittings are used where the conveyor bearings travel.

Projecting fittings would be likely to be knocked off; so the fittings on this Stephens-Adamson conveyor are set into the end of the bearing with the ball check-valve on the high-pressure Alemite-Zerk nipple flush with the end of the wheel shaft. The attendant can lubricate the bearings as the conveyor passes him.



Cross-section of a removable bearing in a gravity roller conveyor.

In many cases the lubrication of gravity rollers is a secondary matter, particularly when ball bearings are used. The bearing is closed but provided with a lubricant which protects the balls from oxidation. In this roller, which is manufactured by The Lamson Company, the bearing unit is removable for inspection and regreasing.

to obtain definite recommendations regarding proper lubrication from the conveyor manufacturer. In general, the efficiency of conveying equipment now in operation for handling package loads would be greatly increased, possible dissatisfaction would be eliminated, and the cost of maintenance would be reduced by much more careful attention on the part of superintendents and maintenance men to the matter of lubrication. It is highly advisable for the Maintenance Department of every plant, if it has not already done so, to introduce a system of periodical inspection of conveying apparatus and attention to lubrication. There are certain installations of conveying apparatus in types of organizations where a regular plant Maintenance Department is not maintained. In such organizations, someone with an aptitude for and understanding of mechanics should be designated to keep the conveying equipment operating efficiently.

Equipment for the storage and handling of lubricating oils and greases will be discussed in another article which will appear in an early issue.

EDITORS' NOTE: Special acknowledgment is given to C. G. Agry, The Lamson Co., Syracuse, N. Y., and to V. D. Green, The Stearns Conveyor Co., Cleveland, Ohio, for assistance in the preparation of this article. Other companies co-operating are: The Bassick Mfg. Co., Chicago, Ill.; Carr Fastener Co., Cambridge, Mass.; Dodge Mfg. Corp., Mishawaka, Ind.; Gifford-Wood Co., Hudson, N. Y.; Hyatt Roller Bearing Co., Newark, N. J.; Keystone Lubricating Co., Philadelphia, Pa.; The Lamson Co., Syracuse, N. Y.; Link-Belt Co., Chicago, Ill.; Mathews Conveyor Co., Ellwood City, Pa.; McCord Radiator and Mfg. Co., Detroit, Mich.; The New Departure Mfg. Co., Bristol, Conn.; Standard Conveyor Co., North St. Paul, Minn.; Stephens-Adamson Mfg. Co., Aurora, Ill.; The Stearns Conveyor Co., Cleveland, Ohio; and The Timken Roller Bearing Co., Canton, Ohio.

Bucket Safer than Handline for Raising Tools

IN MANY plants workmen are forbidden to carry tools or materials up a ladder, because of the danger to the men themselves and to others who may be passing underneath. In consequence it is common practice to use a handline. The handline is let down and the helper ties on the tools or material that is to be raised. This whole procedure often involves much delay, and is more or less dangerous. Sometimes the knots made by an unskilled man slip and the load drops. It is therefore apparent that this method of raising material is a hazardous one.

This danger has been overcome in one plant by the use of a bucket that is large enough to accommodate most articles that are raised by a handline. The principal features of this bucket, which is shown in the accompanying illustration, are that it is deep in proportion to its diameter, and that the heavy bail is fixed rigidly to it. While the bucket is suspended from a rope, a wrench with a handle 5 ft. long can be raised without danger of its slipping out of the bucket, or tipping it.

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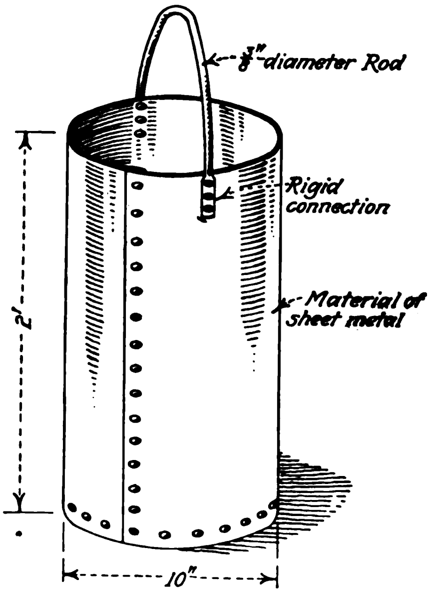

The bail is rigidly fixed to this bucket, to prevent tipping.

Fig. 1—Fumes are drawn away from the surface of these copper plating tanks.

The construction of the box-like exhaust hoods which were placed at the top alongside each tank is shown in Fig. 2. This type of exhaust improves working conditions in that the platers do not have to put their heads into the fumes as was the case with the canopy type of exhaust, Fig. 3, which had been used previously.

Improved Methods of Exhausting Fumes

from metal cleaning, plating and japan spraying operations, that brought about better working conditions and improvement in the quality of product

By C. D. CORWIN

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MUCH can be done by operating industrial engineers towards obtaining better working conditions while making changes in equipment which reduce production costs. An interesting example of this resulted from some studies I made on methods of removing fumes and vapors from acid pickling tanks, plating solutions, and so on. The importance of adequate provision for fume and vapor removal was emphasized during a recent visit to a number of industrial plants. In practically every plant the hood system was used for this purpose and the fumes were drawn up past the faces of the attendants before entering the hood of the exhaust system through which they were removed.

Although this method of removal prevents the formation of heavy steam clouds in the room, it does not eliminate disagreeable working conditions for the operators. When confronted with this same problem nearly three years ago I decided, after studying the conditions, that the place to catch fumes, vapor, and gases was at, or as near to, the point of their generation as possible. At the outset, such a problem appears very easy of solution. As soon, however, as the various factors which must be considered are investigated, the problem takes on an entirely different aspect.

This type of problem is complicated by the fact that the equipment under consideration is usually regarded as non-productive rather than productive apparatus. Or, to put the statement in another way, operating men are naturally seeking production at lower costs and, consequently, either know definitely or, from their knowledge of the situation believe, that this and many other types of problems which they are called upon to solve are classified as an expense rather than tending to reduce costs.

Included in such problems as have arisen along this line, are two which, I believe, will be of interest to many other plant engineers. Available data for the solution of many of these problems seems to be lacking and this is to be expected, although the problems present themselves in some form in every industry performing plating, japanning or similar process work on small parts.

The first of these problems was the design of suitable exhaust hoods for a section of our plating apparatus. In our cleaning and electro copper plating department, iron tanks approximately 24 in. wide by 48 in. long by 30 in. deep are used. The solutions are maintained at about 212 deg F. and as a result considerable steam and disagreeable fumes arise. Also, in preparing brass parts for plating, the successive acid dips give off very disagreeable fumes, one of which is nitrous oxide.

The original system of exhaust hoods followed the common practice of placing the hoods above the various tanks and, to keep them out of the way of the men, the lower edges of the hoods were located about 6 ft. above the floor. Fig. 3 shows the old type of canopy hoods and the manner in which they were installed on the vats at the far end of the room. While this arrangement removed the fumes and prevented the contamination of the air of the entire room, working conditions were not entirely satisfactory. Therefore, a better method of handling the fumes was sought.

The operators require access to one side and to one end of each tank and the steam and electrical connections are made at the opposite end. The tanks, therefore, for ease of connections and operation are set in pairs. Common sense applied to this problem indicated that the place to catch the fumes for removal was at the surface of the tank, thus preventing the operator from being forced to work around and in the fumes.

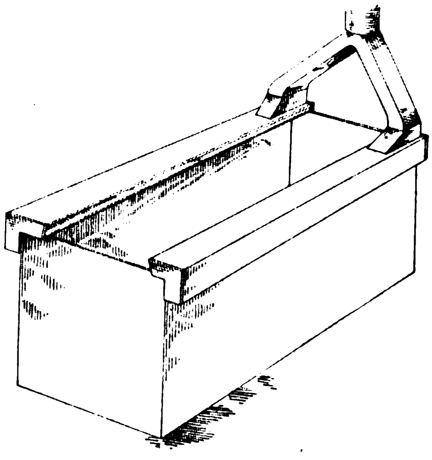


Fig. 2—Perspective view of exhaust hoods on plating tanks shown in Fig. 1.

Fumes or vapors are drawn into the box-like exhaust hoods along both sides of each plating tank through the narrow slots which are placed practically at the surface. In this way the fumes do not rise high enough to bother the plating room workers.

With this idea in mind, two experimental hoods were built up as shown in detail in Fig. 2 and also in Fig. 1, which is a view of the actual installation. These hoods were built in pairs, right and left, to fit on each side of the plating tank. Various suction pressures were tried out on these hoods. Also the width of the mouth or opening was varied in an attempt to determine the best shape and size. These were first made up with a removable strip which could be taken out and planed off. This was done so as to secure a proper opening by trial, as I appreciated that it is practically impossible to take into consideration all of the variables which would enter into the computation of the size of the opening. Comparatively little time and energy were required to reach a satisfactory design.

It was found that an opening or slot $\frac{3}{8}$ in. wide at the end farthest removed from the uptake pipe and tapering down to $\frac{1}{4}$ in. opening at the end nearest the uptake gave practically a uniform suction of air. The suction pressure required at this opening to remove the fumes and vapors was $\frac{1}{2}$-in. water column. Each branch uptake pipe is 4 in. in diameter.

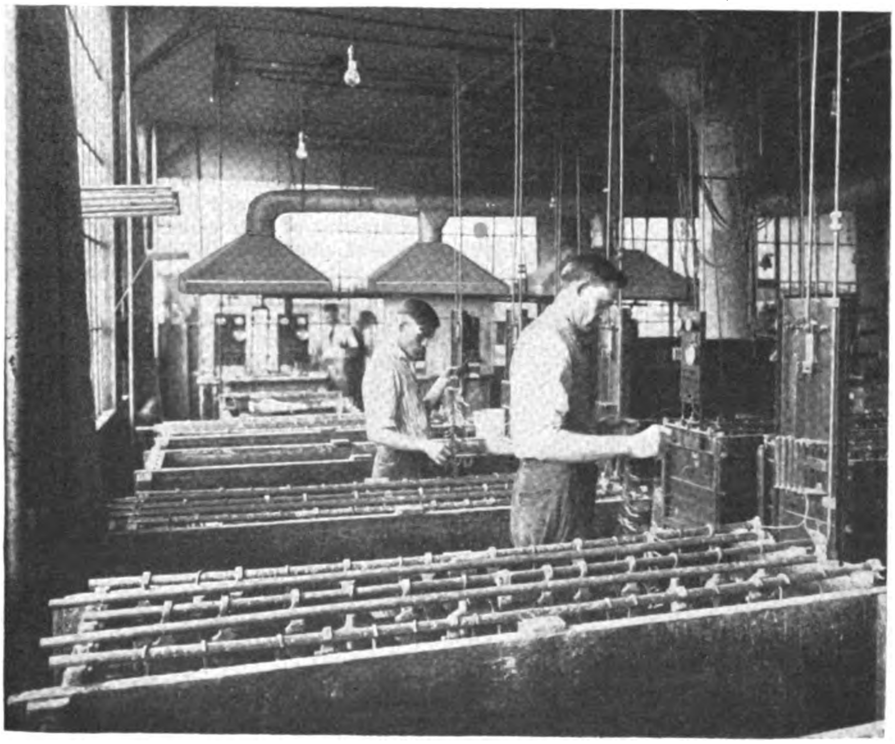
To resist the corrosive action of the moist fumes, the hoods were built up of cypress which was thoroughly painted before assembly with two coats of asphaltic paint and with one coat after assembly to cover all screw heads and the joints. Black iron which was used for the uptake piping, was thoroughly coated inside and outside with an acid-resisting paint of asphaltic base. The use of wood for this piping would have entailed considerably more labor and would not have resulted in as sightly or as tight a construction.

The two uptake pipes from the strong acid dip were made of sheet lead up to a point where they connected to the horizontal run. Sheet lead was also used instead of wood for these two special hoods. It would have been difficult to make these from wood because they fit over circular jars.

Aside from the efficiency of the system, the general appearance of the department was greatly improved by the removal of the large, unsightly canopy hoods, as is easily seen by comparing Figs. 1 and 3.

Another example of an exhaust hood which overcame difficulties and better working conditions is on a booth used for holding the work while it is being sprayed with finish japan. Spray booths, as usually constructed, are of two general types: One type carries its own fan for removing fumes and vapors while the other type, which is built box-fashion, is connected to a general exhaust system. In either type,

Fig. 3—The canopy hoods at the end of the room were replaced as shown in Figs. 1 and 2.



most of the air exhausted from the booth passes around and against the object being sprayed and unless the air is thoroughly washed and the clothes worn by the operators are free from lint and dust, there is sure to be some dust and lint flying about in the air. However, where a mediocre finish is acceptable there is no objection on this ground to the ordinary type of booth. On the other hand, where only products with a fine finish and high gloss are passed by the inspectors, many rejections may be avoided by designing a booth which does not draw air from the room past the work as it is sprayed.

The booth which was designed to overcome this difficulty was made from No. 20 gage black iron and consists of two pieces, the main body or booth, which is quite similar to the ordinary spraying booth, and the enveloping hood as shown in Fig. 4. This hood is made up as a separate piece and fastened to the booth by small bolts with thumbnuts so as to facilitate the cleaning of the booth. For our particular needs, we use a booth proper which rests upon a fixed, flat-bottomed base supported by suitable legs from the floor. The bottom is, therefore, easy to clean by the removal of the booth.

Our typewriter frame receives its finish coat in this type of booth. To facilitate the spraying operation a turntable is mounted on the base which forms the bottom of the booth when all is assembled. An exhaust pipe leads out from the top of the enveloping hood, as indicated in Fig. 4. This exhaust, in turn, is connected to a general exhaust system. In developing this type of booth, various sizes of opening between the hood and the fixed booth were tried out. It was found that an opening 1 in. wide near the base and decreasing to ⅝ in. wide near the top with a 2-in. suction head gave satisfactory results.

A study was made of the currents of air produced by this type of hood, to see how it worked. This was accomplished by using a smoldering piece of waste, which would produce a good volume of smoke, and moving it about in front of the opening of the hood or booth.

Important advantages of this type of booth lie in the fact that it is easy to clean and that only the air current carrying the sprayed material is forced against the object being sprayed. Extraneous matter in the air in the room is immediately pulled to the sides and into the suction openings, and does not get near the newly sprayed parts. This helped us to obtain a product free from dust spots. Also, working conditions are improved because the fumes do not come back into the operator's face, due to the effective suction air screen obtained by the design of the booth.

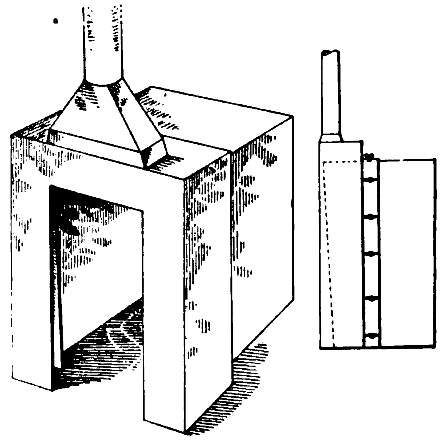


Fig. 4—Arrangement of special hood on spray booth.

Any dust or lint in the air of the room is drawn away through the special hood at the front of the booth and does not pass the freshly sprayed work, as is the case in many types of booths. The sketch at the right shows a side view of the booth; the dotted line indicates the varying width of the exhaust opening.

Factors That Influence Efficiency of Window Lighting

THE fact that dirt collects on window glass and thus reduces its ability to transmit light, is a matter of common knowledge. However, the extent of this reduction under different conditions is not so well known. Interesting data on this subject were presented by W. C. Randall and Allen J. Martin in a paper read before the Twentieth Annual convention of the Illuminating Engineering Society held Sept. 7-10. The data given were obtained for and by the Department of Engineering Research of the Detroit Steel Products Co., and the Department of Engineering Research of the University of Michigan, Prof. H. H. Higbie directing this phase of the investigation for the university.

It is a fairly well-known fact that glass on the slope in the roof of a building will admit more light than will the same area on the vertical, when the glass is clean. However, with dirt collecting faster on the sloping glass than on the vertical this advantage is rapidly lost and at the end of, say, six months' time there is little to be said in favor of the sloping glass.

From the data obtained it is evident that the dirt which collects on glass is not equally distributed on the two surfaces, but that on the average about 75 per cent of the dirt is on the inside surfaces, under usual working conditions. This is probably due to the fact that some of the outside dirt is blown off by wind or washed off by rain, although this may not always be the case in foundries, forge shops, and the like.

There prevails a well-established custom which does much to reduce the efficiency of window lighting is that of giving the windows an annual washing in the spring of the year. During the winter months daylight is at its lowest value and every possible means of utilizing it should be resorted to. Windows washed, say, in May, will have a seven months' accumulation of dirt upon them in December and will be less than 50 per cent efficient, when even 100 per cent efficiency will sometimes inadequately light the building.

If a once-a-year schedule is adhered to, washing in the fall is the most logical time, for then in January, February and March the windows will still be fairly clean and will be considerably more efficient on account of a lighter collection of dirt for the time between a clean condition and the time when lighting by natural means is a problem in many plants.

The data obtained in the studies made permit the following conclusions to be drawn:

(1) The light transmission of window glass decreases with the time of exposure to dirty atmosphere.

(2) The light transmission of window glass decreases with the increase in slope from the vertical, due to the collection of dirt.

(3) There is very little difference in the amount of dirt collected by various types of glass for the same length of time, but some glasses clean more easily than others.

(4) On the average, about 75 per cent of the dirt on windows is on the inside of the glass.

(5) If windows are washed but once a year this should be done in the fall in order to utilize them when the need is greatest in the winter.

(6) A considerable betterment in the natural illumination of a building may be effected by washing the inside of the windows only at shorter periods than is customary when the entire window is washed.

(7) In manufacturing buildings, much dirt can be removed by a damp cloth and at relatively little inconvenience. In most factory buildings some more effective method is necessary.

Special Insulation for Wire Used in Repair Work

with a discussion of the practical details involved in handling and treating these coverings in order to obtain the best operating results

BY A. C. ROE
and
D. H. BRAYMER
Consulting Editor, Industrial Engineer

THIS ARTICLE supplements those that have appeared in the July, August and September issues on wire and insulation used for motor and magnet windings. Limitations of space and high temperature conditions call for special consideration in the size of wire and kind of insulation used. In this article the practical application of silk-covered and asbestos-covered wire is taken up, together with the use of aluminum wire with an insulating oxide coating for motor field and armature coils.

IN THE September issue information was given in tabulated form on the insulation of magnet wire in round and square forms, and the possible substitution of square for round wire in repair work was considered at length. In what follows similar details are discussed for special insulations that are used when small space and high temperatures must be taken into consideration.

Single-Silk-Covered Wire. — Table I gives the insulated sizes of single-silk-covered wire. By comparing the single-cotton covering with single-silk covering (see Table IV, August issue, page 366) it will be found that the insulated diameter of the silk-covered wire is less than that of the cotton-covered wire, but that the insulated diameter of enameled wire is smaller than either of the above insulations.

Wire with single-silk insulation finds very little use in repair work on rotating electrical machinery. A silk covering is better mechanically and electrically than cotton, but the single-silk covering on wire costs more, so that the price per pound of this wire is more than for wire with cotton or enamel insulation. Before the advent of good enameled wire, silk-covered wire was largely used in fan motor work for both armature and field windings, single-phase stator windings and other small motor windings. This covering will stand more handling than will plain enameled wire and for this reason it can be successfully used in the starting windings of small, split-phase motors and in deep windings where the crushing effect of a large number of layers would tend to produce short-circuits in plain enamel-covered wire. Silk covering will not stand heating as well as cotton does, and for this reason it should not be used where the temperature rise is high.

The sizes recommended for a repair shop stock of single-silk-covered wire are Nos. 23 to 30 inclusive.

Silk and Enamel Covered Wire.— With this insulation there are available the single-silk and enamel-covered wire and the double-silk and enamel-covered wire. Table II gives the insulated sizes, pounds per 1,000 ft. and ohms per pound of these wires. These two classes of coverings are seldom used for repair jobs and are employed only in the finest grade of new work where a minimum amount of space calls for a maximum of high-grade insulation.

Gum-Treated Wire.—There is another type of double-cotton-covered wire, termed gum-treated wire. This wire can be used in the stator windings of the old type Westinghouse CCL motors, using a two-layer, diamond-shaped coil, these coils being of the threaded-in type. Gum-treated wire never becomes hard or brittle, but always retains a slight tackiness and has high dielectric strength. When used on shuttle-wound coils the wires hold their shape better than ordinary d.c.c. This wire is a great time saver on breakdown jobs, where insulated, wire-wound coils for open slot machines of low voltage (110 to 550) are required as the coils can be wound on a shuttle, pressed or pulled to shape and insulated, and then given the final dip, thus eliminating the dip before insulating and saving at least 8 to 10 hr. and allowing the job to be pushed through without a stop.

This wire is valuable for use in 1,100- to 2,200-volt coils as a dip before insulating provides a well-treated coil. Gum-treated wire cannot be used to any advantage for mould-wound coils as the sharp bends and pounding ruin the coverings.

Triple-cotton-covered wire is used where high mechanical strength is required, as in large coils using conductors of No. 6 and up to 4-0. Triple cotton covered and enameled wire can be obtained. It has high dielectric and mechanical strength.

Asbestos-Covered Magnet Wire.— This wire is made in round, square and ribbon shapes, under the trade names of Rockbestos, Salamander and Deltabeston.

In making Rockbestos wire, a special cement is used to cement the insulation to the wire. This cement renders the wire moistureproof and gives a finish that helps the insulation to resist mechanical abrasions, while being wound or shaped into armature and field coils, or other types of coils.

Asbestos wire will stand higher temperatures than any other insulated wire. There are three grades of round Rockbestos wire: White, Black and Amber, or Type PN.

The White will absorb machine oil, but will not be injured by the oil. This covering is not impervious to acids or moisture unless further treated.

The Black is impregnated with an asphaltic base: hence it is not oilproof. The ordinary concentrations of acids have very little effect on this covering and it is also practically moistureproof, absorbing 0.25 per cent after 48 hr. immersion in water. The Black will also absorb other impregnating varnishes more readily than the White.

The Amber or Type PN covering is the best for all-around repair shop use, but at the same time it is the most expensive. This covering has all the advantages of both White and Black, and in addition has a higher mechanical strength which permits the winding of more difficult coils.

This class of wire finds its greatest use in the rewinding of over-loaded

Table I—Dimensions, Length, Weight and Resistance of Silk-Covered, Round Magnet Wire

B. & S. Gage	Diameter Bare Wire in Inches	Feet per Pound		Pounds per 1,000 Feet		Ohms per Pound	
		S.S.	D.S.	S.S.	D.S.	S.S.	D.S.
16	.0508	127	125	7.87	8.00	.509	.501
17	.0453	160	158	6.25	6.33	.809	.800
18	.0403	201	199	4.97	5.02	1.29	1.27
19	.0359	253	250	3.95	4.00	2.03	2.01
20	.0320	318	314	3.14	3.19	3.22	3.18
21	.0285	401	394	2.49	2.54	5.12	5.04
22	.0253	505	494	1.98	2.02	8.15	7.97
23	.0226	635	621	1.58	1.61	12.9	12.6
24	.0201	798	778	1.25	1.29	20.5	20.0
25	.0179	1,000	975	1.00	1.03	32.3	31.5
26	.0159	1,260	1,220	.794	.820	51.3	49.7
27	.0142	1,580	1,530	.633	.653	81.2	78.6
28	.0126	1,990	1,910	.502	.523	129	124
29	.0113	2,480	2,380	.403	.420	203	194
30	.0100	3,130	2,960	.320	.338	332	305
31	.0089	3,920	3,680	.255	.272	510	478
32	.0079	4,900	4,570	.204	.219	803	748
33	.0071	6,120	5,660	.163	.177	1,260	1,170
34	.0063	7,650	6,980	.131	.143	1,990	1,820
35	.0056	9,520	8,570	.105	.117	3,120	2,820
36	.0050	11,900	10,500	.0840	.0952	4,930	4,350
37	.0044	14,700	12,800	.0680	.0781	7,670	6,680
38	.0040	18,200	15,500	.0549	.0645	12,000	10,200
39	.0035	22,600	18,700	.0442	.0535	18,800	15,500
40	.0031	27,900	22,400	.0358	.0446	29,200	23,500

NOTE: S.S. equals single-silk covering; D.S. equals double-silk covering.

motors and generators, primaries of welding transformers, no-voltage release coils, holding coils, etc.

The above brings out a word of caution when using asbestos in rewinding any type of apparatus subject to high heat. Use heat-resisting materials throughout. For example, if a coil is wound with asbestos wire it should be finished with asbestos tape and impregnated with Liquid Bakelite so as to make the job thoroughly insulated throughout.

Table III gives the insulated sizes of Rockbestos round wire, B & S gage, and also the weight per 1,000 ft. Table IV gives the insulated sizes of Rockbestos square wire, and the pounds per 1,000 ft.

Another asbestos-covered wire is known as Salamander, Deltabeston and WE Finish. This wire also comes in the White, Black and Amber colored insulation. In this case the white will absorb other varnishes better than the black grade.

A recent development in fireproof magnet wire is to finish the insulation on the outside with an enamel-like compound. In the case of Salamander wire this is known as "WE" finish, the "WE" meaning white enamel. This wire, however, does not have a white appearance. It is passed through a furnace and when completed it is of amber color. A more recent product is the "AV" finish; this has a compound on the asbestos covering which when heated to a high temperature will soften and adhere tightly to the wires next to it so that the entire mass of wire finished with this product becomes a solid coil which will withstand vibration. The two wires having these finishes are, of course, not treated with soapstone, because it is the desire to have the insulation adhere to the insulation of the wires in the next layers in the coil.

Another product which is quite similar to Salamander wire, but which is made on a different style of machine carries the trade name "Deltabeston." There have been some other heatproof wires offered, but cotton or some other covering has been used to hold asbestos tape or some such fireproofing material on to the copper. These products are, however, only semi-fireproof for should the cotton burn out, the wires will become loose and vibrate to such an extent that the fireproof material will pulverize and shake out of place.

White asbestos and single-cotton covered, and white asbestos and double-cotton covered wire is used principally for field coils, in which a large size wire is employed that is wound straight and then bent to final shape, or for coils that require considerable shaping. These coils should always be impregnated with varnish. When the full heat-resisting qualities are required, other heatproof materials must be used in the construction of the coil.

The cotton covering over the asbestos is used for mechanical reasons, to provide space between conductors and prevent the abrasion of the asbestos covering. In armature coils using three or five ribbon or round wires in hand, the even-numbered conductors, as 2 and 4, can be reinforced with one or more layers of cotton and the odd numbers, as 1, 3, and 5 may have just the asbestos covering.

There is another type of insulated wire that is still in the development stage, but has promising possibilities. This is a paper and cotton insulated wire. A layer of tough, flexible, high-grade paper is applied next to the copper and one or more layers of cotton are then applied over the paper. The results claimed are high dielectric and mechanical strength.

Aluminum Wire.—Ever since 1907 aluminum wire with an insulating

Table II—Dimensions, Length, Weight and Resistance of Silk- and Enamel-Covered, Round Magnet Wire

B. & S. Gage	Diameter Bare Wire in Inches	Feet per Pound		Pounds per 1,000 Feet		Ohms per Pound	
		S.S.-En.	D.S.-En.	S.S.-En.	D.S.-En.	S.S.-En.	D.S.-En.
16	.0508	125.9	123	8.00	8.13	.501	.493
17	.0453	158	154	6.33	6.49	.800	.779
18	.0403	199	194	5.02	5.15	1.27	1.24
19	.0359	250	244	4.00	4.10	2.01	1.96
20	.0320	314	306	3.19	3.27	3.18	3.10
21	.0285	395	383	2.53	2.61	5.05	4.89
22	.0253	497	480	2.01	2.08	8.02	7.75
23	.0226	625	600	1.60	1.67	12.7	12.2
24	.0201	785	751	1.27	1.33	20.1	19.2
25	.0179	985	940	1.01	1.06	31.8	30.3
26	.0159	1,240	1,170	.805	.855	50.5	47.7
27	.0142	1,550	1,460	.645	.685	79.6	75.0
28	.0126	1,950	1,820	.513	.549	126	118
29	.0113	2,440	2,270	.410	.441	199	185
30	.0100	3,050	2,820	.328	.355	314	291
31	.0089	3,820	3,490	.255	.287	497	453
32	.0079	4,760	4,310	.210	.232	779	705
33	.0071	5,950	5,310	.168	.188	1,230	1,100
34	.0063	7,410	6,520	.135	.153	1,930	1,700
35	.0056	9,200	7,950	.109	.126	3,020	2,610
36	.0050	11,500	9,670	.0870	.103	4,760	4,000
37	.0044	14,200	11,700	.0705	.0855	7,420	6,120
38	.0040	17.500	14,000	.0572	.0715	11,500	9,220
39	.0035	21,600	16.800	.0463	.0595	17,900	14,000
40	.0031	26,600	19,800	.0376	.0505	27,900	20,700

NOTE: S.S.-En. equals single-silk and enamel covering; D.S.-En. equals double-silk and enamel covering.

Table III—Bare and Insulated Dimensions of Asbestos-Covered, Round, Copper Magnet Wire

Size B. & S. Gage	Bare Wire		Rockbestos Covered Wire		
	Diameter, Inches	Area, Circular Mils	Approximate Diameter Over Insulation in Inches	Approximate Pounds per 1,000 Feet	Approximate Quantity on Reels in Pounds
0000	.46000	211,600	.481	646.9	300
000	.40964	167,800	.431	513.15	300
00	.36480	133,100	.386	408.62	280
0	.32495	105,500	.346	325.05	265
1	.28930	83,690	.310	258.05	250
2	.25763	66,370	.279	205.26	250
3	.22942	52,640	.250	162.87	250
4	.20431	41,740	.225	129.49	250
5	.18194	33,100	.202	102.90	250
6	.16202	26,250	.180	81.86	240
7	.14428	20,820	.162	64.85	240
8	.12849	16,510	.145	51.59	240
9	.11443	13,090	.128	41.02	230
10	.10189	10,380	.115	32.50	230
11	.09074	8,234	.104	25.92	230
12	.08080	6,530	.094	20.64	230
13	.07196	5,178	.084	16.36	220
14	.06408	4,107	.076	13.02	210
15	.05706	3,257	.069	10.37	200
16	.05082	2,583	.063	8.284	190
17	.04525	2,048	.057	6.60	55
18	.04030	1,624	.052	5.287	50
19	.03589	1,288	.048	4.239	50
20	.03196	1,022	.044	3.394	50
21	.02846	810.1	.041	2.713	50
22	.02534	642.4	.038	2.184	35
23	.02257	509.5	.035	1.774	30
24	.02010	404.0	.032	1.424	25
25	.01790	320.4	.030	1.152	25
26	.01594	254.1	.028	.9371	20
27	.01420	201.5	.026	.7442	15
28	.01264	159.8	.025	.6123	15

oxide coating has been tried out for use in field and armature coils and the reason for its restricted use to date will be given in the following discussion.

The one great advantage of aluminum wire is its light weight. For the same cross-section as copper, aluminum has only 30 per cent of the weight of copper. On the other hand, the conductivity of aluminum is between 60 to 62 per cent of the Matthiessen standard, while copper is 98 per cent of this same standard.

Considering two wires, one copper and another aluminum, both having the same cross-section, say No. 1, and both 493 ft. long, the resistance of the copper is 0.062 ohm, while the aluminum wire will have a resistance of 0.098 ohm.

Assume a circuit in which the current flowing is 100 amp. With the copper wire the amount of heat generated will be $100^2 \times 0.062 = 620$ watts. With the aluminum wire having a resistance of 0.098 ohm, to produce the same heating effect, a current equal to $\sqrt{620 \div 0.098} = 80$ amp. approximately, can only be carried. Therefore, to have the same heating, cross-section and length, the aluminum wire can carry only 80 per cent of the current carried by the same size copper conductor.

On the above basis, to replace copper wire with aluminum in an existing field coil, if the size of wire and turns are kept the same, the ampere turns per coil for the aluminum would be 80 per cent of the copper coil for the same heating. Then, to increase the ampere turns, the size of the conductor or turns per coil must be increased. The insulated size of the aluminum wire is smaller than the insulated size of the corresponding d.c.c. wire; therefore, the diameter of the aluminum wire can be increased a small amount to match the insulated size of d.c.c. copper, or if the copper is round, the aluminum can be made square and thus add about 20 per cent to the cross-section. This is the limit without increasing the coil size and if the above does not provide the required number of amper turns at the correct temperature, then the next thing to do is to increase the cross-section and reduce the amount of insulation around the finished coil, or drop some of the turns.

The larger the size of wire the greater will be the difficulty in changing. On the smaller sizes of wire, such as are used in shunt field coils, aluminum can be used, as the percentage of cotton in the coil is greater and this space can be replaced with aluminum. In order to have the same resistance per given length, aluminum wire must have 64 per cent greater cross-section than copper wire. With fine wire copper coils using enamel covered wire, the chances of using aluminum to replace copper are greatly reduced.

Mechanically, the oxide film on aluminum wire is more easily injured than a double cotton covering and the wire cannot be repaired, in the ribbon, square and strap grades, so easily as the copper, insulated wire. Also, soldered joints are harder to make with aluminum wire.

From the above it is obvious that there is little use for aluminum wire in the repair shop.

There is a class of double cotton covered round magnet wire that will be found a time saver in shops where the facilities for tinning coil leads are inadequate. This wire is tinned d.c.c. and can be had in most all of the B & S gage sizes. The bare copper wire is tinned before the cotton insulation is applied.

This wire costs from a half cent per pound more for the larger sizes, No. 9 and up, to 2 cents per pound more down to No. 18 B & S gage. The cost of tinning a set of coils in most cases offsets the extra cost of the material, but the tinned wire makes a better and safer job and also speeds up rewinding work. This applies particularly to coils that are wound in paper cells and sleeved while winding, as it is necessary to push back the sleevings before tinning the leads and pull the sleeves up again after tinning. The use of tinned d.c.c. wire eliminates this extra work, thus saving time and money in the end.

The following remarks pertain to the use of wire in general, and offer some practical hints on handling wire.

Insulated wire from the various wire manufacturers will vary in the quality of the insulated coverings: that is, in the use of different grades of material, the method of applying, and so on. Also, some wire will be soft and other wire springy. The best way to determine which wire is the best for all around, dependable repair shop use, is to make a number of tests. Bend the wire under tension and loose around sharp corners and note the separation of the insulating strands. With insulated ribbon wire bent on edge, it will be found that some grades of wire will skin more when bent under pressure with steel tools than do others.

Make a few tests and select the source or sources of supply that meet with the general requirements. Check the manner in which the wire is wound onto the reels, when re-

ceived. Wire should be put up on reels in even layers and applied and wound on tight, particularly in the smaller sizes, as loose wire on reels will give considerable trouble when used to wind small armatures with coils of a large number of turns when tension is applied to the rim of the wire reel or spool, since the running end of the wire will imbed itself and cause breakage or stretching and waste time in stopping.

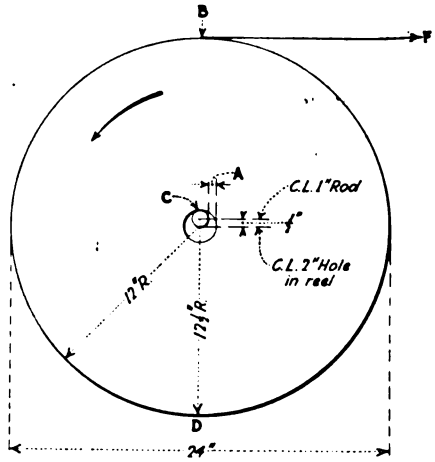
The above is a point to keep in mind when reeling off wire from a full to an empty reel. When the job on hand requires more than one reel of wire, take enough time to wind the wire on the new reel tight and even.

Another point of interest in the use of wire directly from the reel to the winding machine, is to use a supporting rod that has a diameter that will make a sliding fit, through the hole in the reel. A smaller diameter rod will result in a jerky tension, particularly on starting and stopping and at slow speeds. The accompanying illustration explains this. In it is shown a 24-in. reel, with a 2-in. opening, mounted on a 1-in. rod. Note how the reel has an underhung appearance. A pulling force *F* applied at *B* will swing the reel through the distance *A* and then pull up the heavy end *CD*. As the pulling force *F* is released the reel will drop back until the distance *A* becomes normal. This action is repeated at each start and stop. Thus, the use of a small rod tends to make the vertical center line a lever, with the point *C* the fulcrum, *BC* the pressure line, and *CD* the weight line. With the use of a larger rod the swinging distance *A* is decreased, which reduces the rocking until a sliding fit rod makes *BC* practically equal to *CD*, resulting in smoother tension.

Sometimes when bending strap copper on edge around a small pin, the outside edge will crack open, or the strap will split in half. If the strap is being fed from the reel, turning the strap over will reduce breakage.

A pair of ordinary scissors makes a fine wire scraper to use when winding coils with d.c.c. wire, where the leads are skinned before cutting the wire.

When using the scissors, hold them in the hand as for ordinary cutting and open the blades about half-way. Place the open scissors over the wire so that the wire is in the bottom of the V formed by the open blades. Next, hold the scissors so that the



When taking wire from a full reel use a supporting rod that will make a sliding fit.

A small rod tends to make the vertical center line a lever with the point *C* the fulcrum, *BC* the pressure line and *CD* the weight line. With the larger rod the swinging distance *A* is reduced and *BC* is more nearly equal to *CD*, resulting in smoother tension and pull.

blades make an angle of 30 to 40 deg. with the top of the wire and draw the scissors along the wire toward you, at the same time exerting a slight pressure on the scissors, and the cotton covering will fall off, as this method cuts the covering on both sides of the wire. The drawing action should be made quickly.

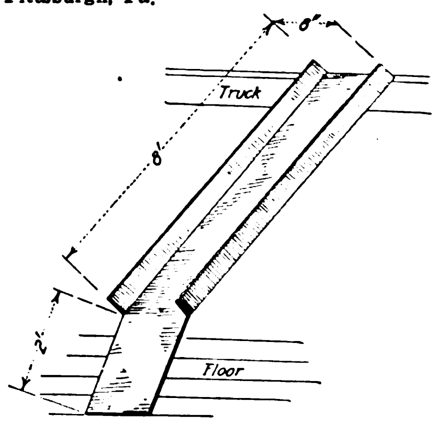
When coils made from d.c.c. wire or ribbon are to have their leads dipped in one or more coats of varnish, before skinning the insulation off for tinning, the wire will be hard to clean, for the varnish will penetrate the cotton covering. A method of removing the treated cotton covering easily is to dip the portion of the leads to be skinned in hot paraffin before the varnish treatments.

Method of Handling Acetylene and Oxygen Tanks

THE use of oxy-acetylene torch cutting equipment in large industrial works has now reached such a stage that a number of truck loads of tanks per day may be required. To reduce the labor cost of unloading these tanks, one large industrial plant uses the following method. A piece of 8-in. channel iron, 10 ft. long, was cut and bent as shown in the accompanying illustration. With this arrangement the truck driver and his helper do not require any assistance in removing the tanks from the truck.

A certain amount of care should be taken when handling the tanks. They should not be permitted to fall or receive other hard knocks, especially on the valve end. The tanks should be stood on end with the valve up and precautions taken to prevent their being knocked over.

D. W. BLAKESLEE.
Electrical Engineer,
Jones & Laughlin Steel Corp.,
Pittsburgh, Pa.



The tanks are removed from truck by means of this slide.

Table IV—Bare and Insulated Dimensions of Asbestos-Covered, Square, Copper Magnet Wire

Size B. & S. Gage	Bare Wire		Rockbestos Covered Wire		
	Diameter, Inches	Area in Circular Mils	Approximate Diameter Over Insulation in Inches	Approximate Pounds per 1,000 Feet	Approximate Quantity on Reels in Pounds
0000	.460 x .460	269,366	.483 x .483	823.1	300
000	.409 x .409	212,948	.433 x .433	650.5	300
00	.365 x .365	169,626	.388 x .388	520.6	280
0	.325 x .325	134,485	.348 x .348	414.1	265
1	.289 x .289	106,222	.312 x .312	327.5	250
2	.258 x .258	82,189	.281 x .281	254.0	250
3	.229 x .229	66,757	.252 x .252	206.6	250
4	.204 x .204	52,880	.227 x .227	164.0	250
5	.182 x .182	42,116	.205 x .205	130.9	250
6	.162 x .162	33,408	.183 x .183	104.1	240
7	.144 x .144	26,396	.165 x .165	82.4	240
8	.128 x .128	20,856	.147 x .147	64.5	240
9	.114 x .114	16,543	.131 x .131	52.1	230
10	.102 x .102	13,244	.117 x .117	41.3	230
11	.090 x .090	10,311	.105 x .105	32.9	230
12	.080 x .080	8,147	.095 x .095	26.3	220
13	.071 x .071	6,417	.086 x .086	20.8	210

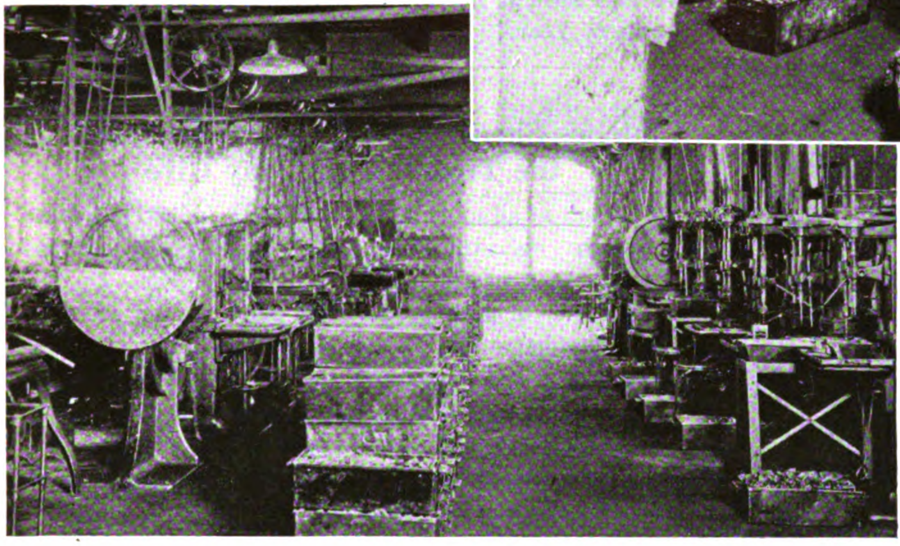
NOTE: Square mils = width in mils × thickness in mils; one square mil = 1.273 circular mils; one circular mil = .7854 square mils.

A PICTURE STUDY

for those who work in

CROWDED CONDITIONS

IN ALL of our anxiety to get things done and to avoid lost motions in the routine of operations, we sometimes overlook the fact that haste makes waste and that the appearance of confusion and a topsy-turvy atmosphere is a serious drawback. Whether it is in a shop or at an office desk, there is



a certain amount of refuse that accumulates. It accumulates so fast, in fact, that unless someone takes the trouble to clear it away, it will be an actual hindrance to good work.

In this connection I want to call your attention to two photographs—one taken before and one after it dawned on the foreman that there was more room in his department than he had thought. Workers had allowed things to pile up and get in the way until it was almost impossible to move the required parts to and from the machines. The upper photo shows just how bad **conditions had become and the real reason for the workmen complaining that more floor space was needed if their machine output was to be kept up to schedule. The lower photo shows what happened one Saturday afternoon, to prove to the machine operators that the basis of their demands for more room was largely imagination combined with carelessness, not to say sloppiness. The camera has done a good job in indicating just what was accomplished. Incidentally the output of this department since the cleanup has been increased, without a kick of any kind.**

Those of us who are responsible for production pay a lot of attention to the speed of machines, to the handling and rehandling of materials in different operations, and to new machines that combine operations, but we pay altogether too little attention to the careless habits of those who work with us and for us. Perhaps this is because a manager or a superintendent or whatever his title may be, when he gets to a position of responsibility, believes that he should move his desk or his office to some isolated spot. When this happens he directs things from afar and does not find wasteful conditions until they get far along. If **he were in the midst of things and the guiding head that he should be, he would be in a far better position to correct carelessness and untidy habits by spotting the one or two guilty parties before their habits spread to others and become a serious matter for correction. Untidy habits are catching, in a way, for it is human nature not to want to clean up after the other fellow or make room for him to further strew his litter around. In most plants floor space is a considerable item of expense whether it is rented or provided by the owner. The providing of additional floor space by new construction is sometimes the difference be-tween a profit and no profit on a year or two of operation, and under such conditions there is little hope of the boss being liberal with the pay slip.**

I hope these two photos may set you to thinking about your own job and the conditions under which you are working. If you can use your head to set things straight about you and take off the brake that is holding back some operation, you have just as good an opportunity for reward as the man who suggests or invents a new machine to accomplish the same end. Brains are at a premium these days and you do not have to look far around you to find

those who make very little use of them. If you will put yours to work overtime as a regular thing on the problems that the other fellow passes by unnoticed you will be surprised sometime to find that you will swell your pay envelope and get where you want to go faster than you have been going. Every boss is looking for just such men and every owner of a business is making bosses of these kind of men.

Practical Pete

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

G. A. VAN BRUNT, *Managing Editor*

Do Not Include the Coke-Fired Salamander in Your Plant Heating System

NOW is the time when most plant maintenance forces are looking around for some means of heating those hard-to-heat or remotely-located corners of the plant where heat is temporarily needed.

It is common practice to use a salamander filled with coke for this purpose. This method is wasteful of fuel, very dirty, requires a great deal of attention, has a debilitating effect from fumes when used in close quarters, and presents a serious fire hazard. Although the practice is to be severely condemned it is commonly used in many plants.

With the many successful devices now on the market for furnishing heat, such as unit air heaters, space heaters, and other forms of electric heat and even economical small hot-water heating systems, the practice of using coke-filled salamanders should not be tolerated. Of course, the first cost of these other devices is higher, but a little investigation will show that this increased cost of installation can easily be justified.

Do Accident Prevention and Safety Work Pay Their Way?

THIS question is satisfactorily answered by a bulletin recently issued by the Bureau of Safety, Sanitation and Welfare of the U. S. Steel Corporation. This bulletin is a review of 25 years' work in accident prevention in the plants, mines, and other operations of this, the largest of all American corporations.

At the end of this period the number of serious accidents per 100 men employed was 60.22 per cent less than in 1906, when the safety activities were started. Also, the number of disabling accidents in 1925 were 80.07 per cent less than in 1912. In round numbers this means 46,900 men have been saved from serious injury, and 322,400 men have been saved from any injury which resulted in loss of time.

In a letter to Judge Gary, Chairman of the Board of Directors of the U. S. Steel Corp., James J. Davis, Secretary, Department of Labor, Washington, D. C., says:

> You are reported as having stated that the United States Steel Corporation in ten years has spent $9,763,063 in accident prevention work and that the money saving resulting therefrom has been $14,609,920, in addition to the fact that 250,000 men have been saved from injury and probably more than 40,000 have been saved from fatal injury. As a self-insurer the United States Steel Corporation is in a position to know whether or not there is an actual money gain to be derived from intelligent accident prevention work, and this statement of the Corporation's experience will be of inestimable value to me in reaching that percentage of employers with whom the humanity appeal does not go very far, and to whom you must show a chance to save money or they will not go along.

Here, then, we have a new appeal for accident prevention. Safety work is a good business investment and will actually show a financial profit of about 15 per cent on the money invested. Surely the last reason for not co-operating 100 per cent in safety work is gone.

Yet from statistics gathered by the Department of Labor we find that the accident rate in the automobile tire industry is three times as high as the average rate for all industries, that the average rate for all industries is about twice that of the electrical machinery manufacturers and that the accident rate of the electrical machinery manufacturer is about five times that of woolen manufacturers. Quite evidently we have by no means arrived at the ultimate goal. But we are off to a very good start and gaining speed all the time. What we now need is not a "No Accident Week" but a "No Accident Year."

Clutches Should Not Always Be Blamed for the Trouble They May Give

IT IS not at all unusual when visiting industrial plants to hear operating men utter broad condemnations of classes or particular types of equipment. On the other hand, in perhaps the next plant visited the very same equipment will be praised. Probably no other piece of power transmission equipment receives such a wide variation of praise and condemnation as do clutches, clutch pulleys, and cutoff couplings. This difference of opinion would indicate that perhaps the fault may be outside the equipment.

Clutches receive, undoubtedly, the most severe operating service of any power transmission equipment. Any increase in the operating speed or the addition of a few more machines adds to the severity of this service. Neglect or improper adjustment also throws excessive strain upon a clutch. None of these difficulties can be considered as due to inherent faults of the equipment.

One industrial engineer has had a group of clutches in service for about 15 yr. without any lost time due to clutch trouble. When he took charge of this plant, the management was considering removing all of these old clutches. He had them rebuilt and had them properly adjusted and the wearing surfaces renewed whenever necessary. Another plant a few miles away called upon the manufacturer of the same clutch for service in less than six weeks after its clutches were installed.

Many other interesting installation experiences are just as contrasting. Much of the trouble encountered is due to overlooking the fact that clutches, like any other mechanism that wears or gets out of adjustment, must be serviced and kept in condition; also, where such equipment is designed for a definite speed, shock, or load, and any of these factors are increased, it is then subjected to an overload.

These same conditions are found to a greater or less

degree in connection with any power transmission equipment. However, the results of neglect or overloading are exaggerated, where clutches are used, because they are more complicated than most other pieces of equipment, and in addition receiving very severe operating service.

The remedy, it appears, must come from both the industrial user and the clutch manufacturer. INDUSTRIAL ENGINEER, through its articles and editorial comments, has emphasized frequently the necessity of applying practical engineering thinking, with operating conditions as its basis, to the selection, installation, operation and maintenance of power transmission and all other equipment. Manufacturers of clutches can help (as some of them have or are doing) by redesigning their equipment so that it will not only meet the requirements of higher speed and more severe service, but be easier to adjust and maintain.

Find the Part You Can Play in Furthering Elimination of Waste in Industry

MANY accusations have been made, doubtless with much justification, that we Americans are the most wasteful people on the face of the earth. Richly blessed with nearly every natural possession of value, we have for generations been wasteful of national resources, as well as time and effort. Part of this has no doubt been due to the lack of any urgent necessity to do otherwise, while part has been occasioned by a lack of co-ordination of effort, which has probably been natural in view of our extremely rapid growth along industrial lines. There are, however, hopeful signs that we are entering a new era in which preventable wastes will be greatly reduced. One of these signs is the wide and increasing interest in Management Week, which is being observed during the week of October 25-30, when more than 300 meetings will be held in 125 cities in this country. Regarding this, Secretary Hoover recently made the following statement:

The general subject chosen for this year's discussion is "Progress in Waste Elimination," and it is planned to have a general audit of the accomplishments and results of the last five years' work by various agencies engaged in waste elimination work. During that period a great deal has been done by organizations acting more or less independently of one another. It is important to discover where duplication of effort is taking place, and where closer co-ordination can be brought about. Programs have been put into practice in various fields that must more or less directly affect allied industries and these interrelations need to be considered. The five-year period is sufficient to allow some measure of the practical results and it is desirable to compare actual with expected accomplishment. That the repeated emphasis laid by industrial leaders, engineers and experts in management on the potential value of waste elimination has had a cumulative effect is shown by the remarkable spread of interest in the annual Management Week meetings. Beginning with 108 meetings in 80 industrial centers in 1924, with a total attendance of approximately 15,000, the movement has grown to a point where this year these figures will have more than doubled.

The subject to be considered is one making the widest appeal to the interest of everyone concerned in the health and stability of American business.

In this great movement some are enabled, by virtue of circumstances, to make more noteworthy contributions than others. Nevertheless, every industrial executive can, and should, through his counsel and co-operation give his whole-hearted support to this effort to put our industrial and business structure on a sounder basis.

Which Is the More Important, the Machine or Its Drive?

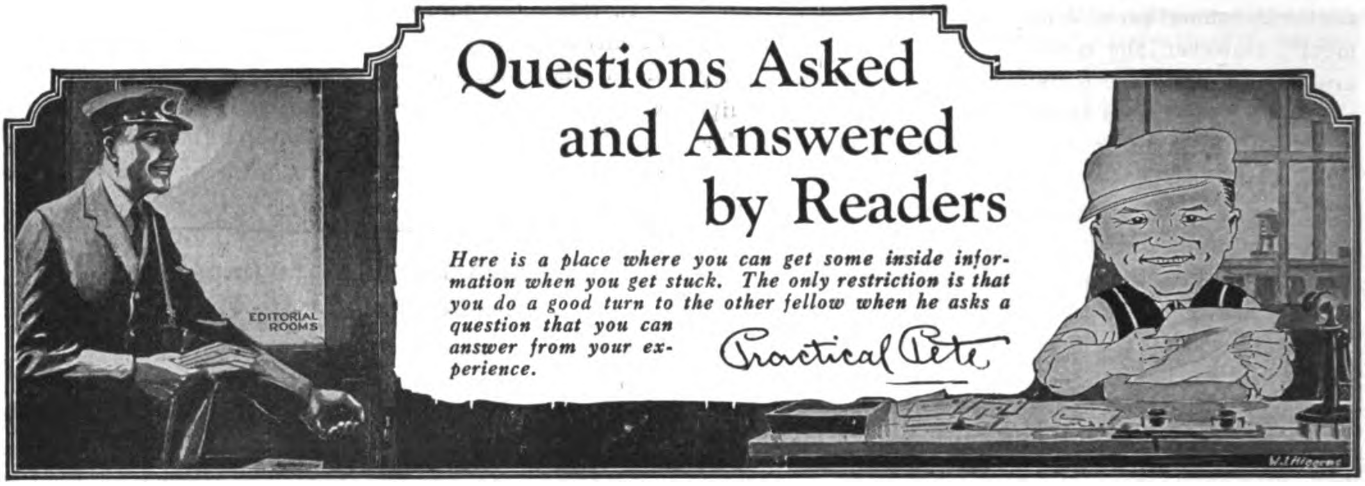
WHEN investigating the trends and practices in the modernization of power drives, one of the most noticeable features found is the increasing tendency to apply sound engineering thinking in the selection and application of equipment. Industrial operating men are better able to do this today than ever before, because the complicated and highly developed electrical and mechanical power drive equipment of the present day requires supervision by trained and thinking men who are familiar not only with the technique of the construction, but also with the operating and the installation considerations.

Uninterrupted operation of production equipment is more important today than ever. Many machines are interdependent because they are links in a chain of continuous production and the stoppage of a single machine for any reason stops the whole group. Production men are putting in the best machines obtainable, in an effort to forestall interruptions due to machine failure, and also to obtain the highest obtainable output at the least cost. Altogether too often in the past, engineering attention was given to the machine and any economies in first cost, if considered necessary, were made in the drive.

Costly experience has demonstrated that a machine is no better than its drive. If the drive fails, even the best machine stops; if the drive does not transmit the power required, the production of any machine is far below its real capacity. To get the best drive requires engineering thinking and careful analysis of the conditions surrounding each installation.

The cost of a suitable drive is in many cases insignificant in comparison to the cost of the machine. A saving of a few dollars on a bearing, belt, chain, pulley, lineshaft, speed reducer, motor, or its control, or any other element of a power drive may jeopardize the results obtainable from the hundreds or thousands of dollars invested in the machine and its drive.

The question, "Which is the more important, the machine or the drive?" is comparable to the old philosophical question, "Which is the more important, the hen or the egg?" Neither can exist by itself. Reliable and efficient operation of any machine requires the application of engineering thought to every detail in the selection of all mechanical or electrical elements involved, and also to their installation and care. Every operating man of today is, or should be, able to do this thinking.



Who Can Answer These?

Lubricating Ball and Roller Bearings.—I wish to know how thin an oil can be satisfactorily used to lubricate ball and roller bearings used in motors. Do readers prefer the use of grease for these applications and if so, why? What are the desirable characteristics of oils and greases that are intended for use on the roller bearings and ball bearings used in motors?
Youngstown, Ohio. E. L.

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Use of Time Switches.—Many times I have felt that clock-operated, time switches could be used to advantage in my plant, for instance on baking ovens and yard lights. Before installing these devices, however, I should like to obtain the viewpoint and experience of readers as to where these switches can be used to advantage around the industrial plant. Where are readers now using these switches to advantage and, also, where do they think they could use them if they were to install them at every point at which they would be of value?
Pittsburgh, Pa. K. E.

• • • •

Soldering Springs in Ammeters—Will some reader tell me the best method of procedure in soldering the springs in electrical instruments of delicate construction, such as ammeters, voltmeters, wattmeters, and the like? These springs are usually made of phosphor bronze, although some other materials are sometimes used. I should like to know what mixture of solder should be used and also what kind of flux is best adapted to the work. Any other hints that readers may give me in regard to the method of soldering will be very much appreciated.
New York, N. Y. L. A.

• • • •

Repairing Roof Tank—We have a yellow pine roof tank used for storing warm water at our plant. This tank is about 15 ft. in diameter and 45 ft. high. It is made of vertical staves which are held in place by means of circular steel bands, much as is the case with railroad water tanks. Four of the staves were apparently not all hard wood and have rotted away so that they are half gone in places, the remainder of them apparently being hard wood, are sound. The tank cannot conveniently be spared long enough to dismantle and put in new staves; so we would like to know what is the best method of repairing it. The rotting of the wood is on the outside only. We have thought of scraping out all of the rotten wood carefully and then filling in the space with a thick cement grout such as is used in fixing up trees where branches have broken away or decay has taken place. I should like to obtain the advice of readers on the merits of this method and also their suggestion on other methods of making this repair.
New Haven, Conn. H. W. F.

Connection for Ammeter and Relays—I should like to know what connection to use on a circuit containing an ammeter, two current transformers, two trip coils for an oil circuit breaker, and some kind of switch that will permit switching the ammeter so as to read the current in each phase of a three-phase circuit. Can I read the current flowing in the third phase when using only two current transformers?
Chicago, Ill. A. W.

• • • •

Changing Speed of Direct-Current Motor—We have a General Electric, Type CO 15, form A, four-pole, compound-wound, 230-volt, 15-hp. motor, serial No. 124206. This motor is rated at 55.5 amp. and a speed of 625 r.p.m. The actual no-load speed, however, is very close to 800 r.p.m., due possibly to some repairs that have been made to the armature winding. Will some reader kindly tell me how I can decrease the speed of this motor to 550 r.p.m.? We would like to make this change in speed by some manipulation of the fields rather than rewinding the armature.
Hannibal, Mo. R. E. G.

• • • •

Cost of Rewinding Stators—I should like to have the experience of readers on the cost of rewinding 60-cycle, polyphase motor stators. Costs that were estimated from the average of a large number of repair jobs, as given on page 347 of Braymer's "Armature Winding and Motor Repair," are as follows:

Horse-power	Synchronous R.P.M.	Average Cost
5	900	$73.75
5	1,200	53.50
7.5	1,200	59.50
7.5	1,800	53.50
10	900	75.00
10	1,200	70.75
15	900	71.25
15	1,200	75.00
15	1,800	73.75
25	600	156.25
25	720	156.25
25	900	143.75
25	1,200	93.75

These costs are, of course, too low as they were taken in 1917 and I should like to obtain the average cost at the present time.
Springfield, Ill. C. L. K.

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Does Magnetized Armature Shaft Cause Overheating of Motor Bearings?—We have a 40-hp., compound-wound, d.c. motor driving a horizontal resaw in a lumber mill. The motor is on the lower floor and the resaw is directly above it on the second floor, with practically a vertical pull on the belt. Some time ago the commutator end bearing ran hot enough to melt the babbitt slightly. The end bell was taken off, and the bearing scraped and pronounced perfect, but it still continues to heat. The bearing on the pulley end of the motor remains cools and gives us no trouble. I notice that the armature shaft and frame of the motor become very strongly magnetized when the motor is running. Would this have any effect on the temperature of the bearings? I shall appreciate it if any of the readers will tell me what is causing the overheating of the commutator end bearing, and should also like to know what causes the armature shaft to become so strongly magnetized.
L'Anse, Mich. H. W. S.

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Answers Received To Questions Asked

Bearings in Wet Locations—It is necessary to operate one of the bearings of a washing device under water. We have not been able to lubricate this bearing and have had considerable trouble due to extensive wear from lack of lubrication and dirt in the water. Babbitted bearings have always been used but I should like to learn the experience of readers with other types of bearings operating under conditions somewhat similar to this. Perhaps someone can suggest a lubricant or method of application which will work. I shall greatly appreciate any information that readers may give.
Des Moines, Iowa. L. D.

If L. D. will use lignum vitæ wood with the end grain to the shaft he will have an ideal bearing for operation under water. It will need no other lubricant than the water itself. If lignum vitæ cannot be obtained, hard maple bearings impregnated with hot paraffine at a temperature not over 212 deg. F. will do.

For convenience in adjustment and taking up wear, I would suggest that he arrange the bearings in four blocks on the quarters with brass adjustment screws and side clamps to hold adjustments. The blocks should have a metal backing to take the pressure of the adjusting screws, and to distribute it over the length of the bearing.
Fort Dodge, Iowa. CLAUDE D. MARTIN.

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Our experience may be of assistance to L. D. in his difficulty with bearings submerged in water. The company with which I am connected, and several other paper mills, have obtained good results by using oilless bushings, which consist of bronze sleeves in which openings in the sleeves are plugged with lubricant. These are used in wet locations without any lubricant or liquid except the water. Most of these installations, however, are not subjected to any considerable amount of dirt or grit, but I suppose if they did they would wear out the same as a bearing does with dirty oil. However, if L. D. has

not already done so, I would suggest that he try one or two such bearings. The cost would be low.

Plant Engineer, H. D. FISHER.
New Haven Pulp & Board Co.,
New Haven, Conn.

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My suggestion to L. D. is that he use lignum vitæ bearings if they are to operate under water. Bearings of this material are used in hydro work and the wood is often referred to as "nigger heads." I know of instances where this wood has been in service for nearly thirty years on hydro units and is still good. The wood is expensive and should be kept under water until used, or it will crack. Also, it is the heaviest of all woods and care must be used in installing it so that the water, which for it is a natural lubricant, will reach all surfaces of the bearing.

Lignum vitæ is a hard wood but may be fitted to a bearing with a hack saw and bearing scraper. Also, a good machinist can mill it. I would recommend it as giving exceedingly good service under the conditions mentioned by L. D. E. J. MORRISSEY.

Chief Electrician,
Western United Gas & Electric Co.,
Aurora, Ill.

* * * *

Water has no lubricating qualities and, therefore, bearings which are immersed in it for all or part of the time are likely to suffer. Bearings such as described by L. D. offer a problem that has not been solved satisfactorily for several reasons.

No engineer will deny that it would be possible to keep water out of a bearing, any more so than it is possible to keep oil in them and away from adjacent parts, such as the windings of the motor, but the cost of the elaborate construction required would seldom be justified. The second factor in importance is that of care: although satisfactory means of lubrication may be provided, neglect of this for a single period of operation may start cutting or wear which will continue to grow worse.

When a shaft or shaft bearing becomes scored, the oil passages invariably become clogged, which prevents the entrance of any more lubricant, that otherwise might keep the surfaces in shape. Often, a scored shaft or bearing provides an opening through which water can enter and dilute or displace the lubricant, which action will quickly result in excessive wear.

The writer has had over 15 years' experience with shafts that were running in water and water solutions. The longest period of immersion noted was 11 years for a 3-in. shaft carrying heavy loads and running at 120 r.p.m. in babbitt bearings. We found that better operation was secured by using cast-iron journals in the babbitt, rather than steel shafting. To permit this, the fixtures were cast with extended hubs about 4½ in. in diameter by 8 in. long which were turned to form a shaft and ran in the babbitt. This gave better and smoother running than on the shafts direct, because steel pitted badly in the liquid, which contained a good deal of vegetable matter. The parts would run for years, but when the bearing wore the pitted journals scored more rapidly and the babbitt had to be renewed. This finally raised the maintenance cost to a point where the renewal of all of the worn parts was necessary.

The question asked by L. D. does not state whether it is a plain or packed bearing which gives trouble. If it is a packed bearing, outside packing will be used, of course, and of a stuffing box construction best suited for the purpose. The simplest type of construction for the bearing section of a plain bearing (not a packed bearing) is the best.

Where it is improbable that gravity or pressure lubrication will receive much attention, it is better to make no provision for lubrication and to spend in many other ways the amount it would cost.

Stainless steel shafting is now made by at least one mill and a number of concerns produce bearing bronzes that are impregnated with a lubricant or have a base composed of one of the white metals.

The writer would use a combination of stainless steel and this bronze bearing, thus obtaining a longer shaft life before corrosion begins, and a bearing material that would not need lubrication.

These bearings should be given a greater area than for similar bearings not operating under water, but they should be so installed that even an unskilled mechanic could make any replacements when necessary. Without knowing further details, I believe that this construction would be superior to one more complicated and, also, it would save money.

Anti-friction bearings can be employed satisfactorily if the machine will stand the expense of mounting and protecting. That it is possible to do this is proven by the widespread use of ball bearings in centrifugal pumps. A study of these might reveal a plan that could be simplified and used to advantage.

A bearing that has stood the test of years in pump work is one in which the shaft is completely encased in a non-ferrous sleeve until it is entirely outside the water zone. That this is imperative for all ordinary steels is well illustrated on automobiles. No matter what price car, the water pump leaks after a time. Tightening up the gland will help for a short time only, because the bare steel shaft corrodes and, as this progresses, the water enters the stuffing box and the packing cannot be kept tight on the rough or eccentric shaft.

The sloppiest job the writer ever worked on was in maintenance work in a paper mill, where practically all shafting and machine parts were in water or subject to drip. The Master Mechanic simplified the maintenance because he insisted that all work be put in so that it could be taken out easily after parts had rusted together or corroded loose. The results showed this to be a good plan.

DONALD A. HAMPSON.

Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Why Do These Motors Stall?—The motors on two Yale and Towne electric hoists are giving us trouble and I wish someone would tell me how to remedy it. One hoist is of 1-ton capacity and is driven by a 220-volt, three-phase, 60-cycle, six-pole motor. The other hoist is of ½-ton capacity and is also driven by a three-phase, 220-volt, 60-cycle motor. If a load of 200 lb. or more is placed on the hooks the motors will stall, although they seem to run at full speed at no load. This trouble started suddenly. The mechanical part of the hoists has been inspected and appears to be in good condition. Your suggestions will be very welcome.

Iola, Kan. T. R. P.

In reply to T. R. P.'s question, my advice would be first to measure the line voltage, as there is undoubtedly something wrong with the voltage at these motors. I once experienced practically the same trouble, due to the fact that someone had reconnected the motors for a different voltage without changing the nameplate data.

If the line voltage is found to be normal, the best thing to do would be to get an experienced winder to locate the trouble.

Chief Electrician, C. L. UMBERGER.
Premier Coal Co.,
Middlesboro, Ky.

* * * *

It would appear that the trouble which T. R. P. is having with the two Yale & Towne electric hoist motors is due to poor contact between the rotor bars and rotor end rings. It is quite possible that this trouble may be remedied by welding the bars to the end rings. If this cannot be done, it will undoubtedly be necessary to obtain new rotors.

Sales Engineer, M. E. HALL.
Electro Dynamic Co.
Bayonne, N. J.

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In answer to T. R. P.'s question I would suggest that if he will look closely at the rotors of these motors, he may find small cracks opened up in the laminations; by clamping or pressing these together, and tightening up the rotor rivets, his trouble will disappear.

We have had several of these motors behave this way, and cured the trouble as stated above. Yale & Towne now make a cast rotor for their hoist motors, and I would advise T. R. P. to secure these new rotors, if his hoists are receiving very hard usage.

N. Tonawanda, N. Y. S. P. CARY.

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T. R. P.'s question indicates trouble at the current source; more than likely there is a bad contact on a switch, fuse or the connection to the trolley wire. It does not stand to reason that both motors would develop the same identical trouble at the same time. An open-circuited rotor, or badly worn bearings could cause this trouble, but T. R. P. stated that the mechanical parts of the hoists are in good condition. Another possible cause of trouble is that the motors may not be receiving full voltage.

I remember a very puzzling trouble that developed in a pump motor installation. The motor ran normally when unloaded, but as soon as the load was applied the motor would come to a standstill. The voltage was supposed to be 220, but we found that it really was only 160.

The voltage should be measured while both motors are running with loads.

As another possibility the transformer that furnishes current may be defective.

Birmingham, Ala. G. H. EMERSON.

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Cause of Heating of Fuse Studs—What causes heating of fuses and studs on our switchboard panel, which is built for three-phase, four-wire distribution? The studs and fuses, which are standard make and rated at 600 amp., heat to the danger point and three fuses have been blown at a load of only 400 amp. The panel on which the studs are mounted is of slate and the spacing and carrying capacity of studs and busbars is more than the Code requires. We have aligned the studs and fuses so closely that a piece of flat steel .001 in. in thickness cannot be pushed in at any point between the clips and fuses. Suspecting loose contacts to be causing the heat, we have used wood clamps on the fuses and clips with no result. Reducing the load from 400 amp. to 200 amp. does not lower the temperature to a point permitting the hand to be placed on the fuse clips. There are no iron washers on the studs and renewable fuses of standard and reliable manufacture are in use. The neutral fuse, however, does not heat. Our voltage is 220 volts across the phases and 127 volts from neutral to any phase. Can this heating be caused by mineral veins in the slate panel? It is impossible to feel any current in the slate by wetting the hands and placing them on the slate. The heated area does not extend back more than 10 in. from the fuse studs and does not reach the main bus which is composed of two 3-in. x ½-in. busbars. I shall appreciate your help on the problem.

Elgin, Ill. A. B. A.

Replying to A. B. A., it is possible that mineral veins in the slate panels will affect the heating of fuse studs, but I am of the opinion that the contact surface is the real cause of the trouble, either in or without the fuse. A current of 600 amp. requires a good-sized contact surface on the studs. Why not try parallel operation of the fuses?

A mistake is often made in fuse rating when doubling or tripling of links: six 100-amp. links will not properly take care of 600 amp.; so due allowance should be made when parallel operation of fuses is used. A larger allowable carrying capacity of fuse contacts should lessen fuse troubles.

Chief Electrician, E. J. MORRISSEY.
Western United Gas & Electric Co.
Aurora, Ill.

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Referring to A. B. A.'s trouble with fuse clips, we have had somewhat the same trouble except that we did not have renewable fuses. Our circuits are straight three-phase, with no neutral. The circuits were fused for 400 and 600 amp. The studs and clips would get so hot that they would set fire to the fuse casings before the fuse would blow.

We traced our trouble to poor contact between the fuse and the clip; so now, by frequent inspections we find the fuses that are heating before any damage is done. Immediately upon the first sign of heating, the fuse is taken out and both clip and fuse block are polished with very fine sandpaper. If this is done before the clip gets so hot that the temper is taken from the copper, no further trouble will result.

But, if you don't get them in time, and the copper gets so hot that it colors up and starts to scale, it is almost impossible to get the clips back to normal.

We had so much trouble with our heavily-loaded circuits, before we found the remedy, and had so many fuse renewals that we have replaced all of our fuse panels with oil circuit breakers, but even these cause some trouble.

Marblehead, Mass. HAROLD H. STEELE.

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With reference to A. B. A.'s question, there is a possibility that a current of 400 amp. is too heavy for the capacity of the studs, that is, that the current density is high compared to the area of the stud. This density should not be over 1,000 amp. per sq.in., preferably 800 amp. Also, if the studs are solid, that is, not laminated, with 60-cycle alternating current the eddy current losses in the copper may be rather high and indicated by heating. It is not likely that current leakage is causing this heating.

Another possibility is that the cables connecting to these studs are smaller than should be used. If these are less than 500,000 circ.mil the cables may be heating and this heat, being carried to the studs, heats up the fuse terminals so that they blow, not from overcurrent, but from conduction of heat to the fuse links.

I have in mind one case where 525-amp. links in 400-amp. fuse cases blow frequently with only 300 amp. in the circuit. A 250,000-circ.mil cable is used in this installation.

East Cleveland, Ohio. L. T. JOHNSON.

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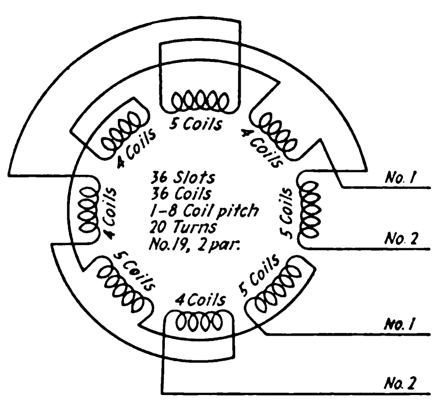
Changing Single-Phase Motor for Three-Phase Operation—I have a General Electric, form C, 60-cycle, 220-volt, 1-hp., single-phase, 1,800-r.p.m., motor connected as shown in the accompanying diagram. The armature has 36 slots, and 36 coils, having 20 turns of No. 19 wire wound two in parallel. The coils are arranged in groups of 4 and 5 coils per

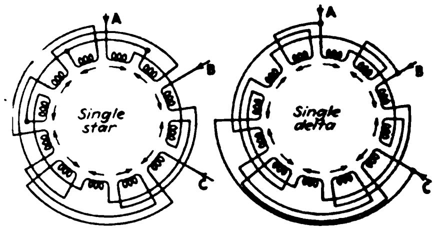


group as shown. (1) How should this winding be connected for use on a single-phase supply? (2) It is desired to connect the motor and operate it from a three-phase supply. Is it possible to change or reconnect the winding to secure this result? I shall greatly appreciate any information or help that readers can give me about this motor.

Brooklyn, N. Y. W. M.

Answering W. M.'s second question, he can change his two-phase motor for three-phase operation by the dead-coil method. The horsepower will then be about 85 per cent of its present rating. When running as a three-phase motor, its running temperature will be slightly greater because the motor will be operating at 96 per cent of its normal voltage.

In the dead-coil method of changing from two to three phase, 80 per cent of the coils should be used, or 28.8 coils, according to the formula. Since this number is not divisible by 12, I would recommend using 30 coils. By so doing a satisfactory arrangement of these 30 coils may be obtained by grouping them, 2, 3, 2, 3, 2, 3, 2, 3, 2, 3, 2, 3. This grouping allows ten coils per phase. According to the figures which were



Method of grouping coils of a single-phase motor that has been reconnected for three-phase operation.

derived from a formula we should have 9.6 coils per phase; so by operating with ten coils per phase the result obtained is practically the same as though the motor operated at a lower voltage with 9.6 coils per phase.

Two No. 19 d.c.c. wires may be wound at the same time, using 16 turns to a coil. An even grouping is obtained by allowing three coils per group.

As shown in the accompanying illustration, the single delta connection should be tried first, and if this arrangement does not work properly, use the single star connection.

Birmingham, Ala. G. H. EMERSON.

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W. M.'s inquiry indicates that the motor is a two-phase machine with an ordinary squirrel-cage rotor. This is an old type motor wherein the necessary revolving field for starting on single phase is obtained by means of phase displacement in the two stator windings. The starting connections are shown at *A* in the accompanying diagram, and at *B* are shown the running connections.

The connections shown in *B* are brought about by opening switch *d* which cuts the reactance *X* out of the circuit, and closing switch *e* shunts the resistance *R* out of the circuit.

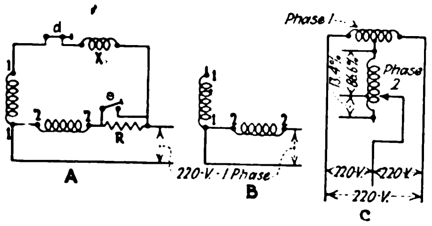
Two single-pole knife switches may be used to open and close the above circuits, but a double-pole, double-throw switch is preferable for then only one handle needs to be manipulated.

In view of the fact that the coil *X* and resistance *R* will be used to carry 15 or 20 amp. for only a few seconds during starting, the size of the wire used in these two coils can be smaller than would ordinarily be used for continuous duty.

If it is desired to use this motor on a three-phase circuit, it will be necessary to use a "T" connection as shown at *C*. You will notice from the diagram that the reactance and the resistance are not required when the motor is operated on a three-phase circuit.

In diagram *C* of the accompanying illustration the midpoint of phase winding 1 is connected to one end of phase winding 2, and 13.4 per cent of phase-winding 2 is cut out. Since 13.4 per

cent of 36 coils is nearly five, the closest approximation to the exact reduction required will be obtained by cutting out six coils. The best way to reduce the phase 2 windings is to cut out coils



Method of operating a two-phase motor from a single-phase or three-phase power supply.

The single-phase starting connections are shown at *A*, and at *B* are shown the single-phase running connections. The connections after a single-phase motor has been reconnected for operation on a three-phase circuit are shown at *C*.

from the four groups, say two coils from each group of five coils, and one coil from each group of four coils.

Commercial Engineer, J. B. HOLSTON.
Wagner Electric Corp.,
Chicago, Ill.

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In reply to W. M.'s second question it seems to me that the motor is of the two-phase type. If so, it is possible to convert it from two phase to three phase, although it would be better to design the winding for a three-phase supply circuit.

In this case certain dimensions should be ascertained before rewinding, such as the axial length of the laminations in inches, the diameter of the bore in inches, width and depth of slot, and so on.

In changing the windings over to three phase, eliminate or cut out one-fifth of the coils in one phase and then connect one tap of the remaining part of this phase to the center of the other phase.

This will give us two ends from one coil group and one end from the other coil group, providing three ends which are available for the three-phase service supply.

Chief Electrician, C. L. UMBERGER.
Premier Coal Co.,
Middlesboro, Ky.

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Burned Spots on Collector Rings—We are having considerable trouble from burned spots on the collector rings of the field of a 300-kva., three-phase, 240-volt, 25-cycle alternator. These spots are about the size of the brush faces and I am at a loss as to what may cause them. Can any readers tell me causes for this trouble and also suggest remedies for it? I shall be grateful for any information that readers can give me.
Petersburg, Va. J. W.

Replying to J. W., the condition described is usually caused by faulty field discharge equipment, or by improper manipulation on the part of the operator.

Sometimes this condition is brought about by a field discharge resistor of too high resistance, or again the resistor may be burned out or damaged.

Electrical Engineer, R. P. DIEHL.
Park City Mining & Smelting Co.,
Park City, Utah.

Answering J. W., burned spots on collector rings may be caused by lightning coming in on the machine, or by the application of other high potentials when the machine is running. Burned spots may also be caused by leaving the alternator shut down with the field current on. Chattering brushes have a tendency to burn the rings, but the burning is distributed about the ring. Loose brushes cause this chattering. The only remedy to be recommended is to true up and polish the collector rings, being particularly careful when working on a steel ring.

Chief Electrician, E. J. MORRISSEY.
Western United Gas & Electric Co.
Aurora, Ill.

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In answer to J. W.'s question, I have experienced similar trouble which in one case was caused by the exciter current being turned on the collector rings of the fields before the field was rotating, and at another time the burned spots on the collector rings were caused by the exciter current being left on after the a.c. generator was shut down.

I would suggest that J. W. test his field winding and his collector rings for grounds. H. J. ACHEE.

Chief City Electrician,
Woodward, Okla.

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In reply to J. W., we have had the same kind of trouble on a 250-hp., 220-volt synchronous motor.

The trouble appeared on one ring only, in the form of flat or low spots, about the size of the brushes, and spaced about the same distance apart as the brushes. We first tried to eliminate the spots by sandpapering the ring with a block. This helped a little, but the sparking would stop only for a day or so.

Next we tried putting on new brushes and sanding them in very carefully, but this did no good. We also tried more tension and then less tension on the brushes, but this did not help.

The motor manufacturer's representative said this trouble did not happen often, but when it did it was very hard to correct, and that sometimes the only way to overcome the trouble was to change the polarity of the brushes.

Finally, as a last resort, before changing the polarity of the brushes, I experimented with the angle of the brush-holder: that is, by tipping or swinging the brush-holders so that one brush-holder was nearer the ring than the other holder.

After several trials, I found a position where the sparking stopped entirely and since then, for a period of several months, there has been no more brush trouble. One brush-holder is now about $\frac{1}{16}$ in. nearer the ring than the other holder.

Before finding a remedy to prevent burned spots on the slip rings, a set of brushes would last only a month, while the set of brushes put in soon after the sparking was stopped as yet shows no signs of wear after 6 mo. of service.

I do not know what caused the spots, although there seemed to be low spots on the ring. This ring is now taking a fine polish, all the sparking has stopped, and the trouble appears to be cured. The trouble did not show up at first, but appeared about 3 mos. after the machine was put in service. The trouble was confined to one ring only. The other ring has given no trouble, and the original brushes on this ring are still in use.

Marblehead, Mass. HAROLD H. STEELE.

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Lightning Protection for Short Overhead Power Line.—We have a 3,300-volt two-phase, 25-cycle, 80-amp. transmission line running a distance of 1,080 meters from our substation to the mouth of our copper mine. At the shaft, this line is spliced to a lead-sheath cable which goes down the shaft a distance of 200 meters where it is connected to a switchboard that supplies other feeders radiating through the mine. The wire and cable used for this transmission line are No. 00 B. & S. gage. The elevation of the country through which the line runs is approximately 4,100 meters above sea level. As the overhead line must have good lightning protection, I wish to install choke coils and lightning arresters at both ends of the line, but I have heard that choke coils should not be installed in connection with lead-sheath cables. Why is this? Won't some reader tell me how to protect this overhead line against lightning? We now have an oxide film arrester at the substation and a compression chamber multi-gap arrester at the shaft mouth, where the overhead line is connected to the lead-sheath cable. Is this sufficient protection? Should I not use choke coils both at the mine mouth and at the substation? What lightning protection would readers recommend for this transmission line?
Pulacayo, Bolivia. C. L. C.

In answer to C. L. C., it would seem that the best protection could be obtained by running a ¼-in. stranded guy wire over the phase wires on the transmission line poles, grounding this static wire at both ends and at its center. This static wire should take care of most of the lightning.

Very strong choke coils should be used at each end of the transmission line, and C. L. C. should be sure to connect the lightning arresters ahead of the choke coils, but no coils should be connected to the static wire.

I would recommend the types of arresters mentioned by C. L. C. always using a choke coil where an arrester is used. Arresters might be also installed on both primary and secondary sides of the substation, care being taken to see that the ground wire is not smaller than No. 4 B. & S. gage copper wire, is well grounded and that all joints are soldered.

If C. L. C. does not care to go to the expense of installing the static wire he will increase the protection of his transmission line by installing choke coils as previously explained.

Chief City Electrician, H. J. ACHEE.
Woodward, Okla.

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Replying to C. L. C., it is in general not considered good policy to install choke coils in connection with lead-covered cables which are more than half a mile long.

The inductance of a choke coil has a tendency to introduce a resonant voltage, due to the capacity of such a cable, which would be very undesirable.

From the description of the installation, it would seem, under the conditions existing, that the installation is fairly well protected. R. P. DIEHL.

Electrical Engineer,
Park City Mining & Smelting Co.,
Park City, Utah.

I would install a static wire grounding it at every post, and also connect a choke coil at each end of the power line together with oxide film lightning arresters in addition to the static wire. This arrangement should provide enough protection.

The static wire that I referred to is a copper wire supported about 3 ft. above the power line for the purpose of picking up lightning; while it is not the usual practice to ground this wire at every post, it would be advisable in C. L. C.'s case.

I can see no ill effect that would result from using choke coils with lead cables, as the lead sheath is itself a very good choke coil, as many have unfortunately discovered in enclosing ground wires in conduit.

Chief Electrician, E. J. MORISSEY.
Western United Gas & Electric Co.,
Aurora, Illinois.

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In reply to C. L. C., choke coils on the substation end of the transmission line, between the arresters and the apparatus, will furnish greater protection.

Choke coils should not be installed in connection with long, lead-covered cables because the combination of the reactance of the coil with the capacity or condenser effect of the lead-covered cable may be such as to produce a condition of resonance, with destructive effect in case of line disturbances. Also, if C. L. C.'s cable is wire armored in addition to being lead covered, or is installed in iron conduit, the cable will produce a sufficient choking effect to force the discharge through the arresters to ground.

I believe that the pellet-type oxide film or auto-valve arrester is preferable to the compression type for positive protection, and at an altitude of 4,100 meters it might also be well to install a set of arresters near the middle point of the transmission line.

East Cleveland, Ohio. L. T. JOHNSON.

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Grouping of Wires in Conduit for Two-Phase System—I have installed some 3-in. conduit runs, to be used for two-phase power supply circuits. These conduit runs are about 25 ft. long. In them I wish to place 500,000-circ. mil cables and since it is possible to get only three cables of such size in a 3-in. conduit, it will be necessary to group the cables in two conduits. Will it be satisfactory to place the two A-phase cables in one conduit and the two B-phase cables in the other? In a three-phase system, this should not be done; hence, I am doubtful about doing it with two-phase cables. Would it be preferable to place one A-phase cable and one B-phase cable in each conduit? If so, which of the two B-phase cables should be placed in one conduit with the first A-phase cable? Please give me some information on these points.

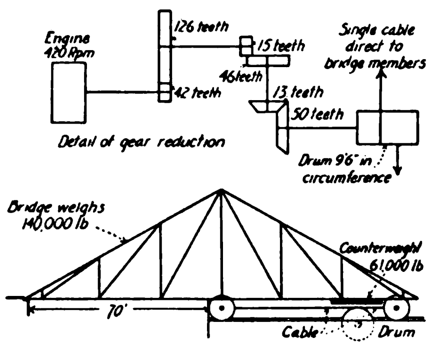
St. Lambert, Quebec, Can. J. M.

Referring to the question asked by J. M., if he puts one wire of the A phase and one wire of the B phase in separate conduits, he will have trouble. In addition, the National Electric Code will not permit doing this.

To avoid trouble, place the wires of A and B phases in the same conduit; otherwise there will probably be heating caused by induced currents in the conduits.

H. J. ACHEE.
Chief City Electrician,
Woodward, Okla.

Size of Motor Required to Operate Drawbridge—I wish to know how to determine the size and speed of motor required to operate a drawbridge that is now operated by a steam engine. The diagram shows the general layout of the bridge. It weighs about 140,000 lb. and travels 70 ft. in 45 seconds. It is supported on four steel wheels 30 in. in diameter with a 12-in. face, running on steel rails. The bridge is pulled back and forth by a steel cable running on a drum which is driven by the engine through a gear reduction; this could be changed to a worm gear



if necessary. The speed of the engine is 420 r.p.m. while the drum turns at 10 r.p.m. I do not know the horsepower of the engine, nor is it equipped to take an indicator card, but the following data may help: Duplex engine (both cylinders receive same pressure); steam pressure, 50 lb. per sq. in.; cylinders 8 in. diameter by 10-in. stroke; speed 420 r.p.m.; non-condensing.

It will be necessary to use a two-phase, 60-cycle, 550- or 2,200-volt motor. I shall be very grateful for any help readers can give me.

Quebec, Que., Can. W. S. B.

Referring to W.S.B.'s inquiry, there is certain information lacking, which must be assumed, and other information given that does not check.

The speed of the cable drum is given as 10 r.p.m., but with an engine speed of 420 r.p.m. the speed of the drum should be: 420 r.p.m. $\times$ (42 $\div$ 126) $\times$ (15 $\div$ 46) $\times$ (13 $\div$ 50) = 11.87 r.p.m.

The bridge travels 70 ft. in 45 sec. which is on the basis of 93.3 ft. per min. In this case the cable drum would have a circumference speed of 9.5 $\times$ 11.87 = 112.7 ft. per min. This speed does not check with the bridge travel of 70 ft. in 45 sec. The given circumference of 9 ft. 6 in. is probably the extreme outside measurement and not the pitch circumference of the cable. Assuming 70 ft. in 45 sec. to be correct, the pitch circumference should be: 93.3 $\div$ 11.87 = 7.86 ft.

The problem can be attacked from two angles: First, by determining the horsepower of the steam engine; and, second, by calculating the horsepower required, basing these calculations on the load, friction, and speed of the bridge. The two answers thus obtained will serve as a general check, one against the other.

The horsepower of the steam engine may be determined by the use of well-known formulas which need not be worked out here, but which indicate that the engine is developing about 81 hp.

Now, to determine the horsepower required, based on the load, friction and speed, assume the weight of the bridge proper as 140,000 lb., and that this load is carried by the two centrally-located wheels. Then each wheel supports 70,000 lb. on its bearings. Taking the weight of each wheel as 1,000 lb., the pressure at the rail is then 70,000 + 1,000 = 71,000 lb.

The coefficient of rolling friction for ordinary tracks varies from 0.003 to 0.005. Let us use the value 0.005. Then, $P = Wf \div R$, where P = pull in lb., W = weight or load in lb., f = 0.005, R = radius of wheel in ft. Solving, P = (71,000 $\times$ 0.005) $\div$ 1.25 = 285 lb., approximately. For both center wheels the pull would be 2 $\times$ 285 = 570 lb.

Next, consider the load on the rear wheels. The counterweight is 61,000 lb., and since we assumed that the weight of the bridge proper was carried on the two centrally-located wheels, the two rear or end wheels would carry only the 61,000 lb. Of course, as an actual fact, we know that the end wheels also carry part of the bridge weight, but what is added to one set of wheels is subtracted from the other set; therefore, to simplify matters we can follow the above assumption.

Assuming that each wheel weighs 1,000 lb., the load carried by each rear wheel is (61,000 $\div$ 2) + 1,000 = 31,500 lb. on the rail. P = (31,500 $\times$ 0.005) $\div$ 1.25 = 126 lb. pull. For both rear wheels, the pull would be 2 $\times$ 126 = 252 lb.

The total pull, required to overcome the wheel-to-rail friction, at the center of the wheels or cable is 570 + 252 = 822 lb.

The friction of the journals will be considered next. The center wheels carry 70,000 lb. each, and assuming a coefficient of friction of 0.2, the friction is, 70,000 $\times$ 0.2 = 14,000 lb. For both wheels, the friction load is 2 $\times$ 14,000 = 28,000 lb.

The end wheels carry 61,000 lb. or 30,500 lb. each. The journal friction on one of these wheels is 30,500 $\times$ 0.2 = 6,100 lb. For the two wheels, 6,100 $\times$ 2 = 12,200 lb. The total resisting force of the bridge equals the sum of the following:

570 lb., rolling friction center wheels
282 lb., rolling friction end wheels
28,000 lb., journal friction center wheels
12,200 lb., journal friction end wheels

41,022 lb. = total resisting force.

Now let us consider the force P required to accelerate the bridge to the speed of 93.3 ft. per min., which is 1.555 ft. per sec. Assume that the bridge starting from rest requires 1 sec. to attain the speed of 1.555 ft. per sec. Then the acceleration is 1.555 $\div$ 1 = 1.555 ft. per sec. per sec. The distance S traveled by the bridge during acceleration is, (1.55 $\times$ 1^2) $\div$ 2 = 0.775 ft.

Then, $FS = (WV^2) \div 2g$; where W = weight of bridge plus three-quarters of the weight of the wheels, or a total of 204,000 lb. V = velocity in ft. per sec., g = 32.16, S = ft.; solving, FS = (204,000 $\times$ 1.555^2) $\div$ (2 $\times$ 32.16) = 7,676. S = 0.775. Then F = 7,676 $\div$ 0.775 = 9,905 lb.

The total pull on the cable equals the force required to accelerate the load plus the retarding forces of friction, or, P = 9,905 + 41,022 = 50,927. Hp. = ($P \times S$) $\div$ 550 = (50,927 $\times$ 0.775) $\div$ 550 = 72 hp., nearly.

The next unit to consider is the cable drum, which I assume to be 7.86

ft. pitch circumference so as to agree with the other data given in the problem. Assume the weight of the drum with a 4-in. diameter shaft to be 1,000 lb. Since the bevel gear, which drives the drum shaft, exerts a torque at right angles to the pull of the cable on the drum, the pressure or load on the bearings of the drum equals:

$W = \sqrt{50{,}927^2 + (50{,}927 + 1{,}000)^2} = 73{,}000$ lb. nearly.

Hp. $= (3.14 \times 0.2 \times 73{,}000 \times 4 \times 12) \div 396{,}000 = 5.5$ hp. Then the total horsepower at the drum drive shaft is $72 + 5.5 = 77.5$ hp.

There are three sets of gears, and assuming that each set, including bearings, operates at an efficiency of 95 per cent, the total efficiency of the three sets would then be $0.95 \times 0.95 \times 0.95 = 0.86$ per cent. Then $77.5 \div 0.86 = 90$ hp. required at the steam engine.

This result checks within 10 per cent of the calculated horsepower of the steam engine, and I believe this result is a comparatively close check.

The three sets of gears and shaft could be eliminated and a planetary spur gear speed transformer connected directly to the drum shaft on one side, with a 1,200-r.p.m. motor on its other side. Considering the service of the bridge to be intermittent, a 75-hp., 1,200-r.p.m., 550-volt, two-phase, 60-cycle, slip-ring motor could be used.

For the electric control, a drum-type controller could be used in connection with a panel containing a main switch, two overload switches and a relay for operating in conjunction with a limit-switch placed at each end of the bridge. When the bridge is near either limit, the motor can be reversed or the bridge may be slowed down by operating the drum handle. If the bridge is operated frequently, and the operating time is an important consideration, then a brake can be used at the motor for stopping.

E. H. LAABS.
Engineer,
The Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

* * * *

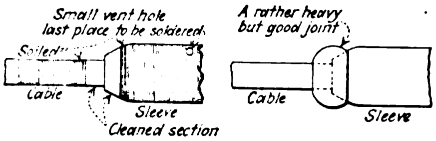
Wiping Lead Joints in Lead-Sheath Cable.—I should like to have readers give me some information on how to go about wiping joints in lead-covered, three-conductor, 2,300-volt cable. I should like to know how to prepare the joint for wiping what materials should be used, how to wipe the joint, and any precautions that should be observed in wiping the joint.

Benoit, Ala. G. E. W.

In reply to G.E.W.'S question it can be said that wiping joints is an art. It requires months of practice, and results in many burnt fingers and spoiled sections of cable. It is not readily taught by books, but rather by apprenticeship to a skilled worker. After paying close attention to his methods, much patient practice is required on the part of the apprentice before he can successfully wipe joints.

If it is possible for you to secure a lead worker, a good plumber or a telephone cable splicer, I would recommend such procedure as most advisable.

A plumber, if a good lead worker, will be able to wipe the joints that need attention and at the same time can give much valuable instruction. He may, however, spoil the insulation by applying too much heat for he is accustomed to using half-and-half solder, a mixture of half lead and half tin. Wiping solder for cable splicing should be done at a temperature which is lower than is customary with regulation plumbers' solder. A solder composed of one part tin and two parts lead, that fuses at 440 deg. F., can be used for cable work, although some workers prefer a still lower working temperature. In order to lower the working temperature under 440 deg. F. a quantity of bismuth may be added. Equal parts of tin (pure), lead, and bismuth will lower the working temperature to 250 deg. F. An experienced man, working in a shielded place which is free from drafts, can produce satisfactory results with a great deal less bismuth than a less skilled workman. With the proportions of the solder in the vicinity of three parts tin, three parts lead, and one part bismuth, the melting point will be 310 deg. F. It is desirable to keep the melting point low so that the joint may be wiped quickly without danger of too much heat running into the cable and weakening the insulation.



Method of preparing a cable joint for wiping.

At the left the cable and sleeve have been shaved with shave hook and the bright surface covered with tallow to prevent oxidation. The right-hand illustration shows the completed joint.

The wiping is done with wiping cloths. These can be purchased in various sizes and several will be needed. R. M. Starbuck & Sons, Hartford, Conn. and J. W. Johnson, Wheaton, Ill. sell wiping cloths. Also both firms handle publications on wiping joints and plumbing work.

For each joint, the quantity of solder varies according to the size of cable and the skill of the worker. This quantity generally varies from ¾ to 2 lb. of solder per joint. Mutton tallow or tallow candles may be used to prevent the bright lead, that has just been cleaned, from oxidizing. Other materials needed in this work are a good firepot or plumber's furnace, a good-sized cast-iron pot, a double-tipped ladle which is not too large, a blow torch, a soldering iron, a shave hook or lead scraper, a compass, a scratch cloth or steel brush, soil which may be purchased in any plumbers' supply house or may be made from lampblack, glue and water which should be stirred up to a stiff paste, a lead dresser for smoothing and working lead sleeve, a turn pin that is large enough for a sleeve, and a drift plug for swaging through the sleeve to make it smooth inside, when a solid sleeve is used.

Now make up an experimental splice of two cables, insulating the splice well with black varnished cambric, and tape each spliced conductor by using more than enough layers for the voltage to be carried. After cutting back the lead sheath, cord the conductors or tape them together, after which insulate them again to a width of 5 or 6 in. each side of the splice. Apply a couple of layers of white cotton tape or use one layer of asbestos paper and around it wrap one layer of the cotton tape; this latter combination will provide the best heat insulation. You are now able to determine the inside diameter of the lead sleeve. The sheet lead can be 3/32 in. thick, although a 1/16 in. thickness is preferable. The over-all length of sleeve can be determined by measuring across the splice from the end of the lead sheath on one cable to the end of the lead sheath on the other. The sleeve should be from 5 to 10 in. longer than the splice depending on how much of a lump has been made at the splice compared to the diameter of the cable insulation. Generally, the inside diameter of the sheath is made only 25 per cent greater than the over-all diameter of the lead cable.

Next, cut the sleeve out of sheet lead, making it about 4 in. longer than the length of the splice, and allow 3½ times the outside cable diameter for the width of the piece being cut. Take the lead-dresser and beat the lead out smooth. Hold the lead sheet on a smooth mandrel, which is of the diameter of the splice, and beat the lead to a tubular shape. This tubular sheathing is now slipped over the splice, spacing it so that the lap at each end will be the same. Scrape the sides that lap for a distance of ½ in. each side of the lap. Scrape and tin this seam with a copper bit, using half-and-half solder. Beat the ends of the sleeve into a cone shape, keeping the surface smooth at each end so that it will join tightly to the lead of the cable. If you have made a bulky splice, it may be necessary to make a larger sleeve, or two small "V" cuts may be made in the ends of the sleeve, although this latter procedure is considered poor practice when a good job is desired.

Scratch the ends of the lead cable with the wire brush for a distance of about 14 in. at each joint. Apply the plumbers' soil and then let it dry well. Then with the compass make a mark around the cable and the sleeve at a distance of 1 in. to 1½ in. from the place where the sleeve joins the cable as shown at the left of the accompanying illustration. Then scratch the cable and sleeve with a shave hook between the compass marks. Cover this cleaned surface quickly with tallow, so as to prevent oxidation.

Secure cable and sheath in a frame or a vise and proceed to wipe the joint. Pour the solder on the soiled sections until the sleeve and cable are heated to the point at which the solder begins to slip off the joint at the bright or tinned parts. Pat solder back to top of joint with the wiping cloth making certain that the bottom and sides are properly tinned and wiped. Finally, before the solder cools and hardens or begins to crumble, wipe or pack the solder into a smooth, even, symmetrical lump over the entire joint as shown at the right of the accompanying diagram, being sure to leave no exposed, unsoldered seams or holes in the sleeve or cable, exception of the vent-hole in the sleeve, which must be soldered up last with a copper bit.

It might be well to grease your fingers and hands with cup grease so

as to prevent the stray solder from burning them too severely. Many little tricks and twists must be found out in practice just the same as one does in learning to swim. By pouring solder on slowly and evenly over the entire soiled section, instead of all in one place, much inconvenience will be avoided. My last suggestion to you is: Don't burn the solder. AL. FIERS.
Tampa, Fla.

* * * *

In answer to G.E.W.'s question regarding the wiping of joints on lead-covered cable, I could be a little more specific in my answer if I knew the size of cable involved, whether solid or stranded, and the type of insulation, whether rubber, paper or cloth.

Cut the ends of the cables so that the wires will have an overlap of at least five or six times the diameter of the conductor. When removing the lead sheath from the ends of each cable, allow a distance great enough for the conductors to be properly spliced. In removing the sheath, care must be taken not to injure the insulation of the wires. It is customary to make a cut around the sheath, gradually increasing its depth until the lead is cut through, or until the lead sheath can be broken off by slightly bending the cable. Make a cut lengthwise from the circular cut to the end of the sheath. Injury to the insulation may be avoided by keeping the knife tangent to the cutting surface. Slightly turn up the ends of the lead sheath into the shape of a bell mouth. Then wrap the wires with cable lacing twine, at the same time working the twine up under the lead.

Select a lead sleeve approximately 25 to 50 per cent greater in diameter than the sheath of the cable and make the sleeve from 14 to 20 in. long, this length of course depending on the size of the cable. The thickness of the sheath should be at least as great as that of the lead covering of the cable. Before slipping the sleeve on the cable, each end of the sleeve is thoroughly scraped with a shave hook, or knife, for a length of about 2 in. and the cleaned portion is then thoroughly smeared with a good flux, such as stearine or a tallow candle. The ends of the cable should be similarly treated. After slipping the sleeve over the most convenient end of the cable, push it back out of the way.

By using a sharp knife the rubber insulation on each conductor can be tapered to a pencil point. Leave a part of the conductor slightly exposed for a length that is greater than half that of the copper connector. If a butt joint is to be used, the two ends of the conductor which are to be spliced, should be sweated together and a copper connector or sleeve of the proper dimension can be used. While the connector joint is by far the most common, stranded conductors may be joined by cutting the wires alternately long and short, and then fitting the ends of the two conductors into one another. After the joint is bound by small gage wire, it is covered with solder and then wiped off so as to leave no sharp projections.

The next step is to insulate the wire connections. The usual procedure is to cover the joint with an insulating tape of material similar to that used for the cable insulation. Wrap this insulation around the connections to a thickness which is somewhat greater than that of the cable insulation. If oiled paper or varnished cambric is used, the tape should be cut on the bias. In this case the cable insulation is tapered gradually to the connector sleeve by means of a sharp knife, leaving a ½-in. space between the cable insulation and the wire connections. The exposed insulation of paper is then dried by pouring over it melted paraffine which is heated to 125 deg. C. Narrow strips of tape should be wrapped in the space between the cable insulation and the connector insulation until this space is built up to the diameter of the cable insulation. Wrapping should be continued back and forth in the space between the two ends of the original paper insulation until this insulation is built up to the level of the cable insulation. Tape is then wound over all the other insulation until a thickness which is about 40 per cent greater than that of the cable insulation is reached, the over-all diameter being a little less than the inside diameter of the sleeve.

In the case of a three-conductor cable, the wrapping should commence at a point on the covered conductor which is 3-in. from the outer belt and continued to a corresponding point at the other end of the joint. The wrapping is continued back and forth, stopping each successive layer ½ in. short of the preceding layer. In applying the tape, each turn should be drawn tightly so as to exclude air, and it should overlap the preceding turn by ⅜ of the width of the tape. In the case of rubber insulated cable, the tension of the rubber tape should be such as to reduce the width of the tape to about half of its original width.

Where cotton or linen tape is used, each layer must be boiled out. Saturate the tape wrapping by pouring hot compound over it until all the moisture is expelled. The temperature of the compound must not be high enough to scorch or make the insulation brittle, although a temperature which is higher than necessary for the boiling of water should be obtained.

Where rubber tape containing sulphur is used, a spirit lamp or warm iron tool may be used to partially vulcanize the tape. The heat should be applied evenly and with care in order to avoid burning the insulation.

After all the conductors are joined and insulated, as described above, tape rolled to a diameter of ½ in. is inserted at the center of the conductors to serve as a spreader. A band of tape is then wrapped around all three conductors to a diameter that will allow it to slide easily into the lead sleeve. For multiple conductor cables operating at 6,000 volts or more, be certain that all the air in the joint is removed. With such cables it is common practice to use insulating joints of prepared paper, varnished cloth or micanite. The joined conductor is then wound with cotton tape up to the level of the original insulation. The joint is now boiled out and after the insulating sleeve is slipped on, a further boiling out follows. With belted cables, a large tube must be slipped over the belt in addition to slipping an insulating tube over each conductor previous to their splicing.

Before the splice has had time to cool, the lead sleeve is slipped into place taking care to see that the sleeve is perfectly dry. The lead sleeve should be held concentric with the cable and the ends of the sleeve made to overlap each cable by about 1½ in. After the ends of the sleeve are beaten down to conform to the shape of the cable sheath, the connection is made tight by a wiped soldered joint. In making the wiped joints, strips of gummed paper may be used to limit the joints. In wiping the joints care must be taken to see that they are made water tight and that the solder is not only smooth but is free from air holes. A small mirror may be used to observe the underneath part of the joint. The one thing that causes more trouble than any other in the process of cable joining is the presence of small blow holes in the wiped joints. With the exception of dry paper telephone cables and some rubber insulated cables, the space inside the sleeve is filled with hot compound by pouring through holes which have been tapped in opposite ends of the sleeve. Pour slowly into one hole until the compound appears at the other and then alternate the pouring first into one hole and then the other until the joint is completely filled. If any moisture appears in the joint, as shown by frothing of the insulation, the compound should be allowed to flow freely out of one hole until all such moisture is removed. After the joint has cooled for a suitable period, say an hour, any settling of the insulation should be compensated by the addition of more compound. It is particularly important not to move the joint until it is thoroughly cooled and especially so with high-tension cables. As paraffin does not adhere to smooth surfaces and as it has an excessive contraction coefficient, it should not be used for filling the sleeve. General Electric compound No. 227 or the Standard Underground Cable Co.'s "Ozite" are good compounds for this work.

After the two vent holes in the lead sleeve are covered with a thin lead cap and carefully soldered, the joint is then complete. When the joint has thoroughly cooled, it should be pushed gently into its permanent place.
Fort Worden, Wash. E. I. PEASE.

* * * *

Changing Wire Insulation.—I am planning to rewind the armature of an Autolite generator. This armature was originally wound with No. 18 single-cotton-covered wire. Can some of the readers of this column inform me what results I will get if I rewind this armature with No. 18 enameled wire? I shall be grateful for your help.
Marietta, Ohio. E. L. W.

In answer to E. L. W., you may rewind the armature with No. 18 enameled wire, without in any way changing the operating characteristics of your machine.

By using enameled wire a better insulated armature will result, and since the outside diameter of the enameled wire is less than that of the s.c.c. wire, no difficulty will be experienced in winding the required number of turns on the armature. C. L. UMBERGER.
Chief Electrician,
Premier Coal Co.,
Middlesboro, Ky.

Electrical Service

around the works

For this section short articles describing ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing, and emergency or special installations.

Simple Method of Checking Progress of Work on Large Installations

WHEN making large electrical installations, it is very desirable to have some method of checking the progress of the work at all times in a simple manner.

An easy method of doing this is to provide the mechanics with sheets of transparent paper of the same size as the sketches or prints. The transparent paper should then be tacked over the print on a suitable board.

As the various pieces of apparatus are installed, their outlines can be traced on the transparent paper directly from the print. Also, as each connection is made, it should be traced on the paper. In this way a continuous check is made which not only shows the progress of the work, but the check is a great aid to the installers in following through the wiring on a complicated piece of work such as a large control board.

Schenectady, N. Y. J. B. RAKOSKE.

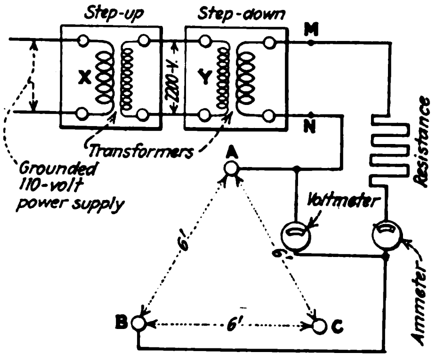
Method of Determining Resistance of Ground Connections

POOR electrical grounds are a source of trouble that is often overlooked by industrial operators as well as by many others. This subject of "grounds," although an important one, is seldom mentioned in the magazines and the textbooks that I read, although faulty grounds are the cause of many men being either killed or burned by coming in contact with electrical apparatus which is either poorly grounded or which is not grounded at all.

In the plant where I was employed last summer, considerable trouble was experienced due to surges. I was detailed to find the cause of this trouble but, before testing the line, I decided to read General Electric Instruction Book No. 85607A concerning oxide film lightning arresters, which book reads in part as follows: "In all lightning arrester installations, good, permanent, low-resistance grounds are essential for the satisfactory operation of the arrester. The efficiency of the best arrester design is defeated by a poor ground connection which causes a loss in protection and, ultimately, damage to apparatus. The greater the importance of the service, the greater is the need of good grounds, and a regular system of testing and inspection should be put into practice."

A search for the trouble on the job assigned to me soon revealed the fact that a lightning arrester was connected to a poor ground.

The resistance of grounds should be tested at least once a year and, if the



The resistance of the different pairs of grounds in series is determined by measuring the voltage drop across them.

When the series resistance of all the different pairs of grounds has been ascertained, the individual resistance of each ground can be determined as explained in the text.

grounds are connected to a pipe which is driven into the earth, the inspection should be made during the dry season of the summer, for the resistance is highest when the soil is dry. The ground connection should never be put where it will be under shelter, unless it is to be kept damp by artificial means.

In most soils satisfactory grounds can be made by driving three galvanized iron pipes into the ground for a distance of about 8 ft., and then the earth should be salted for a distance of about 4 ft. around the pipe. The pipes should be placed at least 6 ft. apart, in this case forming the corners of an equilateral triangle. The pipes should be connected together with lugs so that they can be taken apart, if necessary, for inspection. When the pipes in the ground are 3 ft. apart or more, a satisfactory test can be made for the resistance of the sum of any two individual ground resistances, after they are connected in series, as indicated in the accompanying sketch.

By using a transformer to supply the test current, we have available a test current which is well insulated from the ground, for the secondary side of the transformer has no connection with the primary side. In this case we used two 110/2,200-volt transformers, but, if 2,200 volts had been available, only one transformer would have been used. One of the two terminals on the step-down side of the transformer marked Y was connected to one ground as indicated in the illustration. An ammeter and a resistance of about 5 ohms were connected in series with the other line leading from the step-down side of the transformer Y. The voltmeter was connected so that it would indicate the voltage drop between the two ground terminals A and B.

The resistance of each ground can be determined as follows:

Assume that the sum of the two individual resistances of the grounds, A and B, is to be determined. A fixed resistance of about 5 ohms should be used to limit the flow of current to about 5 amp. Assume that the voltmeter reads 85 volts and the ammeter reads 5 amp. Then, resistance (R) $=$ volts divided by amperes $= 85 \div 5 = 17$ ohms, which is the total resistance of A and B connected in series.

When determining the resistance of $B + C$, say the voltmeter reads 78 and the ammeter reads 6 amp. Then $R = 78 \div 6 = 13$ ohms, the combined resistance of B and C connected in series.

Also, assume that when connected to $A + C$ the voltmeter reads 72, and the ammeter reads 8 amp. Therefore, $R = 72 \div 8 = 9$ ohms, the combined resistance of A and C when connected in series.

The resistance of A can then be determined as follows: $(A + B) - (B + C) = 17 - 13 = 4$. Therefore, $A - C = 4$. The resistance of $A + C$ was determined as 9 ohms. Then $(A + C) + (A - C) = 9 + 4 = 13$ ohms. Consequently, $2A = 13$ ohms, and $A = 6.5$ ohms.

By the same method of procedure the resistance of B is found to be 10.5 ohms, and the resistance of C, 2.5 ohms.

The total resistance of A, B, and C in parallel is determined as follows:

$R = 1 \div [(1 \div A) + (1 \div B) + (1 \div C)]$. Substituting the values of A, B, and C in this formula we find that $R = 1.55$ ohms.

In the event that the resistance of the ground is very low, a standard 110-volt, a.c. voltmeter will be difficult to read when connected as shown in the illustration. So, in this case, the voltmeter should be connected between M and N, and will then indicate the voltage drop across the ground resistance and the fixed resistance connected in series.

In actual operation a faulty ground

is generally much more than 6 ft. from the ground pipes. The result is that the ground resistance in actual operation is greater than indicated by the test, for the resistance through the earth varies approximately as the cube of the distance between the ground terminals. By actual test, when two ground connections are used instead of one, and these grounds are set in the earth 1 ft. apart, their combined resistance in parallel is about 10 per cent less than if one ground were used.

Should these grounds be placed 10 ft. apart instead of 1 ft., their combined resistance in parallel would be about 47 per cent less than if one ground were used.

In order to insure a reliable ground, at least two ground connections should be used and spaced at least 6 ft. apart. Do not locate ground connections beside creosoted poles. When pipes are used, they should be sunk into the earth to a minimum depth of 6 ft. The resistance of ground connections during dry weather should not be more than 15 ohms. C. H. FUNDERBURG.

Maintenance Division,
Detroit Edison Co.,
Detroit, Mich.

Method of Providing Sequence Control for Three Pump Motors

AN INTERESTING system was recently devised for controlling an installation of three squirrel-cage motors, which drive the pumps that supply water to a reservoir, by allowing the water level in the reservoir to actuate a field control switch. It was desired that the motor controls consist principally of a standard automatic starting compensator, an auxiliary control which would give six operating combinations of the three pump motors at six different levels of the water in the reservoir, and that only one of the pumps should operate at certain times. It was further planned to have the other two pumps automatically shut down during these periods and start up again at the end of the shut-down period. These three pump motors are rated at 60, 100, and 150 hp., respectively.

During the winter months ice would foul the mechanism of a float switch; so it was decided to use a Ruggles-Klingemann regulator panel having six control points, each point representing a definite level of the water in the reservoir.

On the panel was mounted a Ruggles-Klingemann regulator, a dial switch, a control circuit switch, a time switch and seven double-pole control relaying contactors. Rather than make up a new dial switch with six points, use was made of a field control switch with 21 buttons. The desired six points were obtained by connecting this switch so as to make seven groups of three buttons each.

In operation, the lowering of the water level in the reservoir causes the regulator to operate by moving the dial switch to the first control point, in this way actuating contactor No. 1 which starts pump motor No. 1 by means of the first automatic compensator. If the water level continues to drop, additional contactors up to the sixth are actuated.

While the dial switch is on any one of the three points, only one motor runs at a time, for when one pump goes into operation the preceding one drops out. Pump No. 3 operates on the fourth, fifth and sixth points, as well as on the third point. As the dial switch moves to the fifth and sixth points, additional pumps are picked up at each point. That is, pump No. 1 is added at the fourth point, at the fifth point pump No. 1 drops out and pump No. 2 is started up, and on the sixth point all three pumps operate simultaneously.

In order to permit operation of but one of the pumps during certain periods, a time switch together with one of the control relaying contactors were used. The normally closed tips of the time switch were included in the coil circuit of the contactor, and the control circuits of the two automatic starting compensator panels were wired in series with the contactor. During the period when two of the motors are temporarily cut out, the tips of the time switch open and the contactor drops out, thus allowing only one pump motor to operate, regardless of the position of the dial switch.

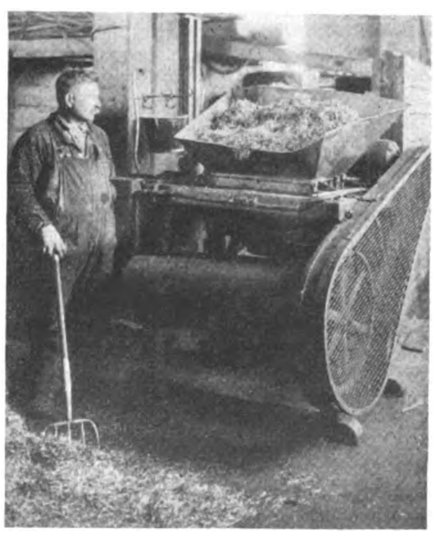
General Electric Co., Schenectady, N. Y. B. S. HAVENS.

Method of Separating Iron from Monel Metal Turnings Saves $20,000 A Year

BY THE use of a magnetic roll, for separating iron and steel turnings from Monel metal scrap approximately $20,000 is saved annually in the General Electric plant at Schenectady, N. Y.

Formerly, approximately 70 gross tons of mixed metal turnings were scrapped each year, as no method was known of separating the high-value Monel metal from the cheaper iron and steel.

Mixed metal turnings then were sold for an average price of $15 per gross ton, while clean Monel metal turnings brought approximately $300 per gross ton.



By regulating the current flow, the strength of the magnet is adjusted so that it will attract iron and steel, but not Monel metal, turnings.

Many methods of separating the two kinds of scrap had been tried without success. The magnetic method was tried but was not at first successful because the Monel metal was also picked up by the magnet. It was eventually found that by adjusting the current flowing through the magnet a point could be reached where the strength of the magnet could be sufficient to retain only the iron and steel turnings, thus separating them from the Monel metal turnings. The machine used for separating the turnings is shown in the accompanying illustration at the bottom of this page.

During the cold weather a clean separation was difficult because of oil congealing on the turnings and holding them together. One of the plant workmen suggested that the turnings be dried on large steel plates or in a large shallow pan heated by a fire beneath it. This scheme was tried and was found to be successful.

Comment on "One More Reason for Standardizing General-Purpose Motors"

IN THE October issue, page 488, there is an editorial entitled "One more Reason for Standardizing General-Purpose Motors," in which is brought out the fact that the Chief Electrician in a plant where there were 240 motors was in very bad shape on account of the fact that no two of them were alike.

It is perfectly true that if it were possible to standardize motors, all we would need would be to have the same size, same shaft, same dimensions throughout.

This would indeed be a very great help, but the other side of it is this—standard motors don't remain standard very long. In other words, there is no motor of any popular make, on the market at the present time which was on the market five years ago. As an average, every five years or even less, every manufacturer brings out a new line of equipment; so if a user started out to standardize just because he bought from the same manufacturer all the time, the user would be off standard within a comparatively short time.

Anyway, it does not seem to me that this matter of standardization is anything like such an important matter as it might appear on the surface. All the spare parts that any manufacturer carries for the usual line of general-purpose motors is spare bearings, and it is not going to cost more to carry these spare bearings for 17 different makes than it is for one, particularly when the size of the bearing generally varies with the size of motor.

Standardization is a very important matter, but it is not a God-send.

Vice-President, J. F. LINCOLN.
The Lincoln Electric Co.,
Cleveland, Ohio.

NOTE: The purpose of the editorial mentioned was to show one more reason for standardizing general-pur-

pose motors; there was no intention to claim that the main reason for standardizing motors is the reduction in spare parts. The chief advantage from standardizing general-purpose motors would be the interchangeability brought about by standardization of their external dimensions. On this question we would like to have the comments and viewpoints of other readers, particularly as to whether they favor the standardization of general-purpose motors, and why.—EDITORS.

Lock to Prevent Closing of Knife Switch

IN MANY plants, especially those which have been in existence for many years, open knife switches are quite common on the main switchboard. As a means of preventing unauthorized persons from closing switches when the electricians are working on branch lines, the writer devised a switch lock, shown in Fig. 1 in the adjoining column.

The main part of the device was cut from a sheet of ⅛-in. red fiber. Two iron ears, shown in Fig. 2, were attached to the fibre sheet by means of ¼-in. stove bolts, the ends of the bolts being riveted over the nuts to prevent them from being unscrewed when the device is in service. A railway switch lock is used to lock the device in place, and no one except the electricians is allowed to have keys to this lock.

On 400-, 600- and 800-amp., three-pole switches the ears of the locking device are slipped over the center blade of the switch. On 1,000-amp. switches with laminated blades, one ear of the safety devise is passed between the blades on the middle leg of the switch, the other ear being outside of the outer blade on the same leg.

Due to the fact that the ears are not placed in the exact center of the fiber sheet, this safety device can be turned

Fig. 1—When this device is locked to one of the blades of a knife switch, the latter cannot be closed accidentally.

upside down to fit various other types of switches on our switchboard. Therefore, this one device can be used to lock out any switch on our distributing switchboard—thus making for Safety First. The electricians have a great deal of confidence in this device and it would no doubt be found useful in many other plants.

Chief Electrician, U. S. Gypsum Co., Alabaster, Mich. C. A. PETERSON.

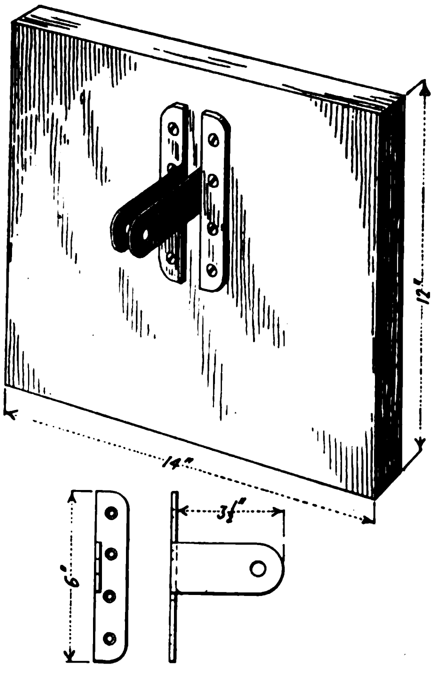


Fig. 2—This shows how the knife switch lock is made.

Comparison of Insulation Resistance and Dielectric Strength

THERE seems to be confusion in the minds of some engineers as to the difference between dielectric strength and insulation resistance, as applying to electrical apparatus generally, and consequently there is some lack of appreciation of the value of making insulation resistance tests. We are all so familiar with the general practice of applying a high voltage for the purpose of testing motors, generators, transformers, and the like, that there is danger of overlooking the insulation resistance test, which gives results of equal and often greater usefulness. The writer offers the following comments as indicating the value of insulation resistance testing, both in addition to, and entirely apart from, the so-called high-potential or dielectric strength test.

All electrical insulating materials have two fundamental electrical properties: (1) Resistance to the passage of current, or insulation resistance, and, (2) strength against breakdown under static or high-voltage stress, or dielectric strength.

Insulation resistance is expressed in ohms or megohms (millions of ohms), and is proportional to the thickness of a perfectly homogeneous insulating material and is inversely proportional to the area under test. For this reason the insulation resistance of a short piece of wire or cable is higher than that of a longer length. The values can be obtained quite readily by a number of different methods, one of the simplest and most reliable of which is the Megger method referred to below.

Dielectric strength is expressed in terms of the voltage at which the insulation punctures at some point, due to static stress, and can be measured only by testing to failure, similar in principle to the way samples of building materials are tested to destruction.

Now, insulation resistance is not ordinarily a measure of the voltage required to cause an actual breakdown or puncture of the insulation, although frequently the insulation resistance test is a guide in this respect, as pointed out in the following paragraphs. But here is a fact which apparently few appreciate—a piece of electrical apparatus may successfully undergo a rated or specified dielectric strength test and still have relatively low insulation resistance. Low insulation resistance means increased current leakage to ground or to other conductors, and may be due to a number of causes, such as deteriorated insulation, or moisture, or both, or to dirt or corrosion at terminals. There is no way that the high-voltage dielectric test can indicate this condition without breaking down the insulation at some point, and even then, one only knows that the insulation was weak at that particular point. Furthermore, high-voltage testing does subject electrical equipment to serious risk of unnecessary and permanent injury, particularly old equipment where the application of high-voltage is "playing with fire," as far as trouble is concerned.

The so-called high-potential test is only part of the whole story in testing electrical apparatus, and actually, in many instances, it gives only a small part of the total information which one needs to know about the condition of a motor, generator or cable, and other apparatus.

It is common practice to apply high potential to new or repaired electrical apparatus. Experience has shown, however, that much electrical equipment will have a lower insulation resistance after a high-voltage test then preceding it, showing that something has happened which in all probability should not have happened. For example, if the insulation resistance of a repaired 50-hp. induction motor measures 2 megohms it is likely to measure as low as 1½ megohms or lower, after the motor has apparently successfully undergone a high-potential test. There is no way in which the high potential will indicate this weakened condition, unless it is carried to the point where the apparatus breaks down entirely.

Applying a high-potential test is somewhat like suddenly dropping four or five times normal load into an elevator which, if the rope stands the strain, is expected to carry you and a normal load up eight or ten floors. How do you know whether or not you strained that rope to the breaking point when you applied the breakdown test? It might have been more to the point to inspect the elevator rope carefully for broken strands, and as to how much it has stretched in its life, or would stretch under a given load.

There are many electrical operators who consider it worth while to make an insulation resistance test both before and after the high-potential test. Unnecessary breakdowns can be largely prevented by this method if a suitable

standard is maintained, and to that extent the insulation test is a guide as to the amount of high voltage which it is safe to apply. It should be clearly understood that the high-potential test is not replaced by the insulation resistance test on new or repaired apparatus. For example, $\frac{1}{32}$ in. of air space between a misplaced conductor and the frame of a machine may have good insulation resistance, but would readily break down under high voltage. However, such a failure usually is not a question of insulation, but of workmanship.

One will seldom risk the application of high voltage to a motor or cable, which apparently is all right, but which needs to be checked as to its condition. Manufacturers do not recommend this practice, and common sense will tell any one that the risk is unnecessary. It is here that the insulation resistance test is of greatest value: it does no harm to the apparatus being tested and it shows on a direct-reading scale what the condition of a motor or generator is relative to deterioration, moisture, or dirt accumulation. Insulation resistance varies considerably with temperature and humidity, but it takes very little practice on the part of an alert electrician to determine the condition of a piece of electrical apparatus, by means of an insulation resistance test. Regular tests and records are helpful in this connection. If a 100-hp. motor had 10 megohms insulation resistance a year ago and tests once a month or so have shown a falling off until now the insulation resistance is less than 1 megohm, there is ample warning that something is wrong. Your own general acquaintance with that motor will tell you approximately what and where the trouble is. The insulation test tells you that it is there. On the other hand, you may have another 100-hp. motor of the same type which has held consistently around 1 megohm for the past year, possibly up to 1.5 or down to 0.8 megohms, depending on specific conditions when the tests were made; but that machine is all right even though its insulation resistance is the same now as the first motor, which ought to be up to its own normal of 10 megohms. It is common practice to use 1 megohm as a safe working standard for much electrical apparatus, but actually the insulation resistance is relative, the same as a barometer or temperature reading is relative. The question is. Is it rising or falling?

In the hands of an alert, intelligent electrical engineer a megohmmeter or insulation-resistance measuring instrument is a powerful tool, and the results obtained far outweigh the money spent for it and time consumed in using it.

The practice of making insulation resistance tests has grown steadily during the past 10 to 15 years, and it would appear that the subject is destined to receive much more general attention and be given wider application. Particularly will this be true on account of the increasing necessity for uninterrupted service while plants are in operation, and the further economic advantage of preventing unnecessary trouble.

T. B. WHITSON.

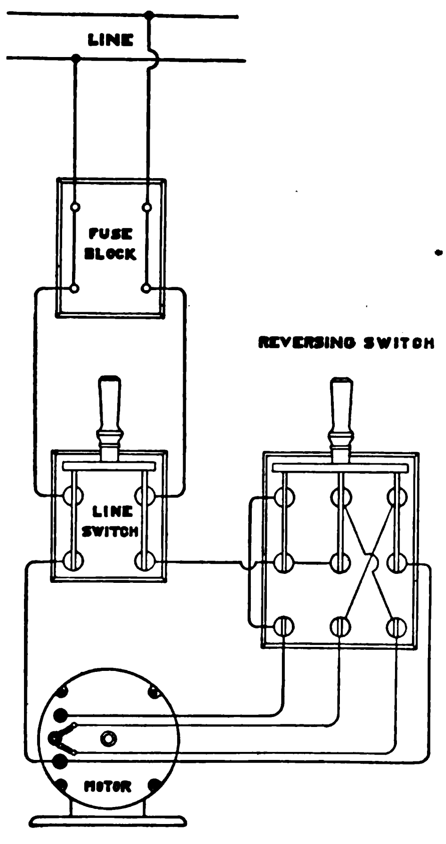
James G. Biddle,
Philadelphia, Pa.

How to Reverse Direction of Rotation of Split-Phase Motors

DIRECTION of rotation of most split-phase induction motors may be easily reversed by simply transposing the leads from the starting coils, outside the motor frame. In cases where it is necessary to reverse the direction frequently, it is advisable to install a three-pole, double-throw switch, as shown in the accompanying diagram, which is recommended by The Emerson Electric Manufacturing Co., St. Louis, Mo., for use on its stock types of split-phase motors.

The leads from the starting coils, from the central bushing on the motor, are connected to two jaw studs of the reversing switch and are cross-connected to the two corresponding jaw studs on the opposite side. The two corresponding blade studs are connected, respectively, to one of the main line wires and to one of the motor binding posts. The third pole of the switch is used as a single-pole line switch to open the circuit and stop the motor.

The operator must allow the armature to come to a full stop before the switch is closed. If the phase coil connections are reversed without breaking the circuit and allowing the motor to come to rest, the armature will continue to rotate in the same direction. It is only at starting that the influence of the phase or starting coils is felt; hence the necessity for the third pole of the switch to break the circuit.



A three-pole, double-throw switch connected as shown here will facilitate frequent changes in the direction of rotation of a split-phase induction motor.

Obviously, a two-pole reversing switch, without the main line connection, would answer the purpose if the circuit were broken by operating the main line switch simultaneously with the reversing switch. However, the use of the three-pole switch involves but one operation to break the circuit, reverse the motor, and start it in the opposite direction.

How Single Brushes Caused Reversal of Polarity on Generator Exciter

THE following instance of reversal of polarity was recently brought to the writer's attention, and brings out a point in fundamental design which seems important.

Certain steam turbo-generators were installed with direct-connected exciters. One day the operator was called on to leave the generating room for a few minutes and, while away, the lights went out and almost instantly lighted up again. At the time, only one generating unit was in operation.

He noticed, upon returning to the generator room, that all the direct-current instruments read in the reverse direction. As no connections had been changed or touched since the units had been installed and there had been no circuit troubles, so far as could be learned, it seemed logical to assume that whatever the cause might have been it was present in the unit itself. After a thorough and careful examination, the cause was discovered more or less by chance at the exciter that was directly connected to the generator.

The exciter was a very small one of the bipolar type, and had only two brush holders with a single carbon brush per holder; due to a brush sticking in its holder after being raised from the surface of the commutator by a high commutator bar, the direct-current circuit was momentarily opened, thereby cutting off both the exciter field current and main unit field current.

The inductive discharge of the main field caused the exciter polarity to reverse and, as the vibration of the exciter set caused the brush contact to be again made almost instantly, the exciter built up again in the reverse way. As it was possible at this station to parallel the exciters on the different units, the condition had to be rectified.

This could have been done by crossing the leads at the switchboard, but it was obviously a method to be avoided. It was then demonstrated that the theory of the cause of the trouble was correct, for by lifting one of the brushes momentarily the polarity of the exciter was restored to its correct condition.

The knowledge gained from this rather novel experience is that any d.c. generator, no matter how small, and particularly one used as a generator exciter, should never have less than two brushes per set, as the likelihood of both brushes losing contact at the same time is extremely remote.

C. OTTO VON DANNENBERG.

Electrical Division,
General Engineering & Management Corp.,
New York, N. Y.

Mechanical maintenance of

Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through the auxiliary transmitting equipment to all driven machines.

Elevator Operator Services Belts in Small Plant

AT ONE Michigan plant, in which the work consists largely of assembly operations and there are comparatively few machines scattered over the four-story building, it was considered advisable to have a belt maintenance man, although there was not sufficient work to keep him busy. A study of other intermittent duties in the plant indicated that the elevator service was intermittent enough so that one of the elevator operators could also serve as the belt man. This man keeps belt tools and lacing supplies in a bench built in along one side of his elevator car so that they are always convenient for him whenever he receives a call on any of the four floors.

This elevator operator was formerly employed in a large factory on maintenance work but became too old for continuous service at this more difficult task. In this plant the belt work requires a comparatively small portion of his time; the larger proportion is given to the operation of his elevator. In addition to making repairs on call, he is able also to repair loose laps and trim belts at his bench in the car, and make occasional inspections of the belts in the plant so as to keep them all in good condition.

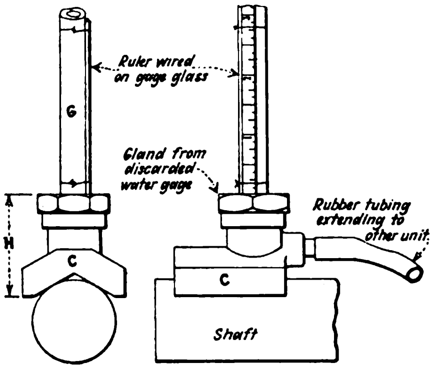
Easily Made Water Gage for Leveling Line Shafts

ON ONE occasion we were confronted with the task of lining up a shaft that passed through two brick walls, and this prompted us to make the leveling set shown in the accompanying drawing. As in practically all old buildings, the floors had settled unevenly and carried the lineshaft with them. The work was made more difficult because the 30 ft. between the two walls was a sort of dark well so occupied as to make this section of the shaft virtually inaccessible at the point we needed.

This one job, and the fact that we often had shaft leveling to do, induced us to construct a leveling set that would be independent of hand levels, and yet could be used with them when desirable. We made this as a "water level" outfit and first joined the two gages by 60 ft. of tubing; since then we have used as much as 150 ft. of tubing on some jobs.

The cost was low because picked-up parts were used for everything but the bases and the tubing. A simple pattern was made for the base *C* and two of them were cast in gray iron. It would have been better to use brass, but this iron set has worked out very well in practice.

The castings were planed off on the lower flat side and the V cut in on both pieces at the same time to insure that they were made the same size. The upper round riser was turned and threaded in an engine lathe and to this was fitted the gland from a discarded



A pair of these shop-made water gages was used to level a shaft extending through two brick walls.

water glass; the pair of glands answered for the set. Two sections of old gage glasses *G* were cut off, the sharp ends smoothed, and then thoroughly cleaned. These were clamped upright by tightening the gland nuts.

The side outlets were drilled and tapped for ¼-in. pipe and half of a 3-in. nipple was screwed in each hole. These side holes, of course, joined the holes in which the glasses were set. Rubber tubing was worked over the nipples until securely gripped.

It was necessary to tighten the nuts so that the height *H* was the same on each gage. Two 6-in. rulers were purchased, sawed lengthwise, and all but the narrow beveled edge, which is graduated, was discarded. These strips were wired to the glasses, as shown, to provide the graduation at very little expense or trouble.

With this equipment, it was a very simple operation to place one member of the set on the shaft in the first room and get a reading of the height of the shaft in the third room. This reading showed a difference of $\frac{5}{16}$ in. in this case, part of which could have been detected with hand levels, but not so easily or as accurately, unless we had been able to get at the shaft in the intermediate room.

Even in a room with 100 ft. of shaft, all exposed, a water level is a great help. It often happens that, after starting to level from one end and adjusting each length of shaft up or down to the other end, it is found that the adjustment should have been made either higher or lower at the start because of some belt condition or due to insufficient range in some of the hangers. By using the set described, an idea of the difference in level between the ends or at any other points may be gained in a few minutes without making any laborious changes that may prove to be wrong. This quick check is very similar to the "preliminary levels" which the surveyor runs over a piece of ground to determine its general characteristics before putting in grade stakes and making other necessary preparations.

As a suggestion for others who may wish to make such a set, it is best to use large-sized tubing because there is then less water friction and a better chance to get all the air out.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

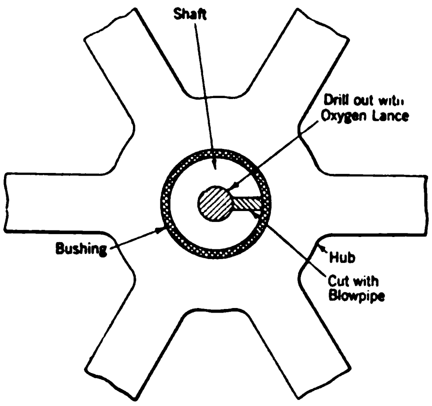
How to Remove Frozen Shaft by Use of Oxygen Lance

ONE OF the most troublesome problems for a shop man is to remove a frozen shaft or crankpin from a gear or pulley with simple equipment. A method of doing this with a cutting blowpipe and an oxygen lance, as recommended by The Linde Air Products Co., New York, N. Y., is as follows: An oxygen lance consists of a length of ⅛- or ¼-in. iron pipe and a piece of oxygen hose. This assembly is connected to the oxygen regulator in the usual way.

To cut out a frozen shaft, the first step is to cut off the shaft with the cutting blowpipe near the pulley hub on both sides. The pulley is then placed in a horizontal position so that what is left of the shaft will be vertical, as shown in the accompanying illustration. With a welding blowpipe heat a spot in the center of the shaft end to a bright red heat. Direct the oxygen lance against this hot spot with oxygen at about 10 lb. pressure, passing through the ⅛-in. pipe. A hole will be drilled rapidly through the shaft, the pipe in the lance being consumed meanwhile. It may require more than one length of pipe for one deep hole, and the oxygen pressure should be gradually increased with the depth of the hole, to blow the molten metal and slag up out of the hole. The hole should be drilled all the way through the shaft in this manner.

While the metal is still hot, slot the

shaft on one side with the cutting blowpipe as shown in the acompanying diagram. This slot can easily be made to the edge of the shaft through the whole length of the shaft section remaining



Method of removing solid pulley or gear when frozen on shaft.

First cut off the shaft at both hubs, and then drill a hole through the center of the shaft with an oxygen lance as shown. The shaft is slotted to the hub of the pulley with the cutting blowpipe and then can be knocked out easily.

in the hub by starting it on the hot edge of the lance-drilled hole. When the shaft is drilled and slotted in this way, it can easily be knocked out. If it still sticks, however, extend the slot from the hole to the further edge.

Precautions to Take When Rebabbitting Bearings

IN THE rebabbitting of bearings the following three factors are of prime importance: The bearing metal, the temperature at which it is poured, and the temperature of the shell and mandrel. The composition of the babbitt should be suitable for the service conditions. The two principal factors determining the composition of the babbitt are speed and pressure. In high-speed operation with a light or medium pressure, it is well to use a babbitt with a fairly high percentage of lead. For severe operating conditions, due to high pressure, at any speed, a relatively high percentage of tin must be used in the bearing to give sufficient compressive strength. As bearings operate under a wide variety of conditions intermediate between the extremes of pressure and speed, a correspondingly wide variety of bearing compositions may be used. The accompanying table indicates some of the alloys which have been found satisfactory for various purposes as indicated.

The best composition for any particular service is dependent upon operating conditions and may be made valueless by heating the metal to too high a temperature, or by pouring it when it is too hot or too cold. Greater care must be exercised in seeing that a lead-base babbit is used at the proper temperature than is the case with a tin-base alloy. For this reason, it is well to use electrically heated melting pots with some type of thermostatic control, which will heat the metal to a certain temperature and keep it there until used.

The first step in babbitting a bearing is to clean the shells, which may be made of cast iron, cast steel, steel or bronze. Cast-iron or cast-steel shells are usually used without tinning. When rebabbitting an old bearing all of the old babbitt must be removed by heating the shells until it is melted out. Oil, dirt, or other foreign matter attached to the shell may be removed by dipping it in a strong solution of caustic potash or by burning. If the latter method is used the presence of smoke indicates that all oil and dirt have not been burned off the shell.

The next step is to scrape the surface to remove any scale. Steel or bronze shells, which are usually tinned, may be cleaned by heating them, preferably in a pot of scrap babbitt, until the old metal is melted out. As soon as the old metal is removed, the tin surface should be cleaned by coating it with zinc chloride; then dip the shell into a pot of molten solder (50 per cent tin and 50 per cent lead) which should be maintained at a temperature between 630 and 670 deg. F. Best results will be obtained by babbitting these shells while they are still hot and without handling. If permitted to cool, the tin surface should be wiped off before refilling.

Composition of Babbitt Adapted for Various Bearing Services

Application	Tin	Lead	Antimony	Copper
Shafting and heavy machines........	80	..	10	10
	75	..	15	10
	70	10	10	10
Bearings on machine tools and millwork	55	25	15	5
	50	27	19	4
	20	40	37	3
Light machines.....	10	75	15	..

When tinning a shell it is necessary to cover the parts on bronze or steel shells which are not to be tinned with a clay wash or thin mixture of graphite and water. When this is dry, the parts to be tinned should be swabbed or washed with zinc chloride and the shell then immersed in a pot of molten solder which should be maintained at a temperature of about 680 deg. F. The shell should be permitted to remain in the solder until it is heated through. This is indicated by the excess of solder running off quickly when the shell is removed. A thin coating will, however, remain on the surfaces to be tinned.

It is well to remove the shell from the solder pot and again rub the tinned surfaces with zinc chloride and dip into the solder bath as before. This operation should be repeated as long as any spots which have not been thoroughly tinned can be detected. For tinning solder is preferable to babbitt in that it has a lower melting point.

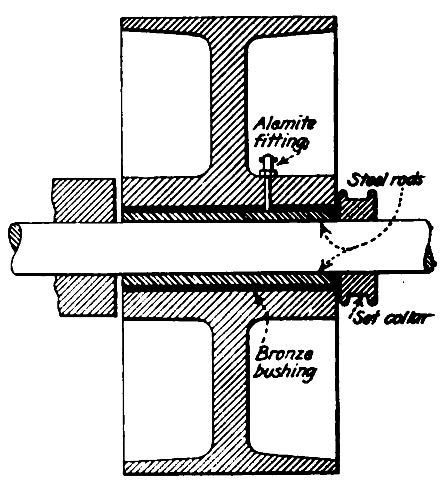
The rate at which the bearing metal cools after it has been poured is very important and can best be regulated by pre-heating mandrels and shells. Ordinarily, for cast-iron or cast-steel shells which are untinned, the mandrel is preheated to about 300 deg. F., and the shell to around 210 deg. F. If the shell is too hot, the metal will cool too slowly, which sometimes results in a partial segregation of the metal in the alloy that may make one part of the bearing too hard and another too soft. Where the shell is too cold, the babbitt metal in contact with it is chilled too suddenly and may shrink away from the shell. The use of oil on the mandrel is objectionable because it causes blistering. Satisfactory results can usually be obtained by coating the surface of the mandrel with a clay wash applied with a rag.

If necessary the mandrel may be cooled between pourings by dipping it in the clay wash, instead of swabbing. The proper temperature of the mandrel is indicated by the clay wash drying quickly, but without spattering. As stated before, the bronze or steel shells are preheated in the tinning process and should be babbitted immediately.

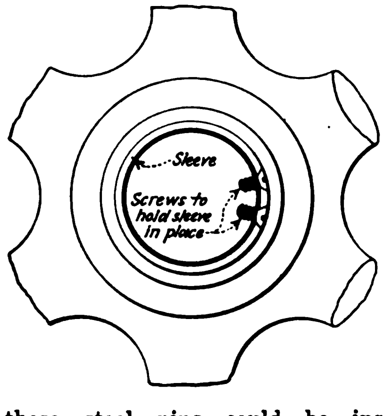
Using Steel Rollers to Overcome Loose Pulley Trouble

CONSIDERABLE trouble was experienced with seizing of a loose pulley on a shaft in a saw mill. At first the bushing was reamed out a little. This was unsuccessful, however, because it gave the pulley a slight wabble, which threw the belt. This plant was not only located in an out-of-the-way place, but as it was an old mill it was not desired to make any expenditures for new equipment which was not absolutely necessary.

As the purchase of a new pulley was out of the question, the following expedient was resorted to and has overcome the difficulty. The hub was bored out and fitted with a brass bushing securely held in place with dowel pins, as shown in the accompanying sketch. A number of ground steel rods of ½-in. diameter were cut to the length of the hub. The ends were cut off true and squared. The sharp circumference at the end was rounded off slightly with a file. The brass bushing was then bored out sufficiently large so that



The pulley was fitted with a brass bushing and a simple roller bearing made by inserting a number of ½-in. steel rods between the bushing and the shaft.



these steel pins could be inserted around the outside of the shaft and the inside of the bushings. This provided a makeshift roller bearing of the type used in toy wagons and other similar applications. A steel plate was attached to the ends of the hub to prevent these rollers from working out. Lubrication was supplied by means of an Alemite fitting. With adequate lubrication this bearing should last for a long time. Since it has been installed no further trouble has been experienced. M. C. COCKSHOTT.
Union Rock Co.,
Azusa, Calif.

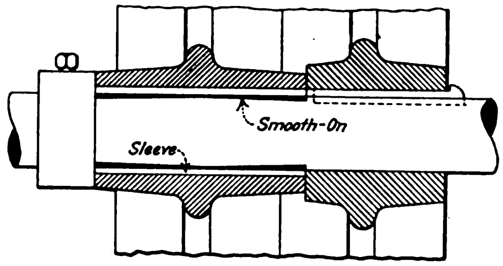
Repairing Worn Shaft Under Loose Clutch Pulley

ONE of the most inconvenient repairs to make on a lineshaft is building up the worn spot caused by a loose clutch pulley. Frequent practice in such cases is to cut out a section of shaft, but this is expensive and inconvenient as well. One method of making a repair of this nature, as reported by H. L. Weber, Master Mechanic, Louisville Woolen Mills, Louisville, Ky., is shown in the accompanying illustration.

In this plant a $2\frac{15}{16}$-in. shaft was worn at a loose clutch pulley to $2\frac{5}{8}$ in. under one edge of the pulley and $2\frac{1}{2}$ in. under the other. The clutch would no longer hold and could not be kept cool when running idle. The installation of a new piece of shafting seemed to be the only remedy. However, renewal of the shaft would have cost about $50 for material, required 26 hr. labor and cause at least 31 hr. production loss in the 20 per cent of the mill in which production was dependent upon this mainshaft.

After considerable study, the repair was made as follows. The high spots on this worn section of the shaft were filed down and a piece of $2\frac{1}{2}$-in., extra-heavy pipe $7\frac{1}{2}$ in. long was turned down to $2\frac{7}{8}$ in. outside diameter and then split on one side only with a hacksaw. Three $\frac{3}{8}$-in. screw holes were drilled and countersunk on each side of the saw cut. The pipe was then slipped and driven over the shaft to the worn place, clamped tightly, and the shaft drilled and tapped to receive the screws which hold the pipe tightly in place, as shown in the accompanying illustration.

When this was done, the pipe just touched the shaft at the high spots on the $2\frac{1}{2}$ in. diameter section, but left



A piece of extra-heavy pipe was turned down and slotted to fit over the worn spot on the lineshaft. It was then screwed to the shaft and the void between the sleeve and the shaft filled with Smooth-On cement.

an open space between the pipe and shaft at the $2\frac{3}{8}$ in. section and intervening spots. The ends of the pipe were temporarily filled with putty to form a mold, and a thin mixture of Smooth-On No. 1 and Smooth-On No. 3 were poured into the crack left by the hacksaw. The pipe sleeve was tapped slightly with the hammer during the pouring so that the mixture would completely fill the void.

The inside of the clutch pulley bearing which had worn conical, and tapered to the center, was bored and bushed to the new diameter, $2\frac{7}{8}$ in., and slipped over the pipe sleeve. The repair was allowed to stand until the next morning to give the mixture time to harden and form a substantial support for the pipe sleeve. When put into service the clutch operated satisfactorily.

The entire cost of this repair was about $3 for material, labor 10 hr., and approximately 10 hr. of production loss on the 20 per cent of the mill which was dependent upon this clutch for its power.

Recommendations for Lubrication of Ball Bearings

IDEAL lubrication for a ball bearing consists of an oil circulating constantly in an ample, but not too ample, volume and with only slight pressure. "Ideal" is used advisedly, because an ideal is something that can be attained only with the greatest difficulty and trouble, if at all, which is exactly the case with the above method of lubricating ball bearings.

Five main difficulties, however, lie in the way of oil lubrication: (1) Heat is generated by the churning of the oil at speeds as low as 300-400 r.p.m. unless an overflow is provided to maintain a proper level; this churning and heating increases proportionately with the depth of the oil and the rate of speed. (2) Oil, being a liquid, is hard to retain in a housing. This is especially true because under the churning action of the moving balls the oil is vaporized and floats out of the housing. (3) Owing to vaporization and other factors, oil requires frequent renewal. (4) When shafts are not revolving, the force of gravity draws the oil to the bottom of the housing, leaving the bearing dry and exposed to rust; filling housings full enough to cover the balls at all times results in the above-mentioned churning and heating. (5) Oil is more expensive than grease.

From this it will be seen that, however "ideal" proper oil lubrication might be, it is almost impossible to attain it within reasonable bounds of expense and under the average service conditions.

With the object of simplifying the lubrication problem and obtaining a practical, satisfactory lubricant the Fafnir Bearing Co. have in the past few years devoted considerable time to lubrication experiments. As the result of these tests the general use of grease has been recommended at all speeds and temperatures and for all sizes of bearings; this does not mean that on some applications oil will not give as satisfactory service, but that grease on these applications will give equal if not better service with less trouble.

This recommendation is based on the following points: (1) Grease of the proper consistency does not work out of the housing. (2) Enclosure design is simplified. (3) Grease applied with a modern type of gun is kept perfectly clean. (4) Grease does not need as frequent renewals. (5) Grease does not sink to the bottom of the closure when the bearing is idle. (6) Suitable greases are easy to obtain. (7) Inasmuch as grease tends to fill the space between shaft and housing, it assists materially in keeping out dirt. (8) At high speeds the rise in bearing temperature is less than with oil.

The essential properties of a suitable ball bearing grease are: (a) Consistency a little stiffer than vaseline; generally No. 2 or 3 as graded by automobile grease manufacturers. This is important, as a grease of this consistency is stiff enough not to churn at high speeds, yet soft enough not to dry. (b) No abrasive or body-giving matter, such as talc, graphite, or pumice. (c) Mineral base—not vegetable or animal grease.

For normal speeds, 300 to 1,500 r.p.m., grease renewal once a year is ample. Under any conditions the most frequent renewal is every three months. At time of renewal the housing should be filled up until some of the old grease works out, which can be wiped off. This is also a good time to note the quality of the grease last used and to see whether it has hardened. The tendency of grease to dry out is what really determines the frequency of lubrication.

Greases that will meet the above mentioned specifications have been giving many of our customers satisfactory service for years, and we believe they have greatly simplified bearing lubrication. Users of ball bearings are invited to send samples of their greases to the Fafnir Bearing Co.'s laboratory for analysis and approval. This service is rendered for the good of the ball bearing industry and has no strings attached.
Chief Engineer, H. R. REYNOLDS.
The Fafnir Bearing Co.,
New Britain, Conn.

In the Repair Shop

This section is devoted to repair work on electrical and mechanical equipment. Special attention is given to shop or bench tools and short cuts or improved methods of handling work of this character. Contributions are always welcome.

Care of Mica Segments in Commutators

THE mica segments which insulate the commutator bars from each other occasionally need careful checking up, otherwise, poor commutation will result.

In the construction of a commutator the copper strips or bars are held together by a steel and iron cage, the bars being insulated from each other by mica strips.

The expansion and contraction of the copper bars has a tendency to push out the mica strips above the surface of the commutator. Should the mica be pushed out only a very little, the commutation of the motor or generator will be seriously affected.

In order to appreciate more fully the conditions under which a commutator functions, it is interesting to estimate just how frequently each brush makes and breaks contact with the commutator segments. This may be done by multiplying the revolutions per minute of the commutator by the total number of commutator segments.

It can readily be seen that contacts may be made and broken many thousands of times a minute. With even slight sparking at each make and break it does not take long for the bars to become burned and pitted. Sometime when the machine is not running, it may be interesting to observe by the use of a magnifying glass just what happens to the commutator bars when the brushes make a poor contact.

Again, from the forging it can also be seen that a commutator segment is in contact with a brush for a very small fraction of a second.

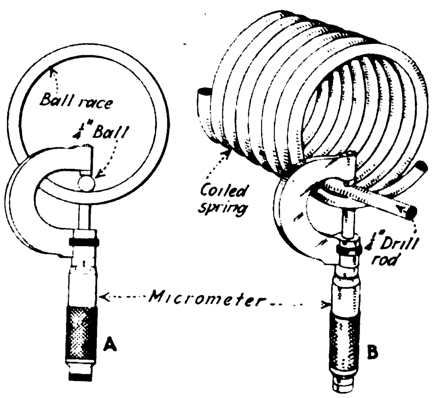
Some brushes contain a very fine grit which helps to grind away the mica whenever it moves above the commutator surface. The employment of these brushes is not the best method of overcoming the troubles caused by the high mica strips, for grit mixed with the graphite, dust, and a very fine oil mist makes a very good glaze material. This glaze is a good insulator, the electrical resistance of which is the cause of most of the heating of the commutator.

Undercutting, whereby the mica is cut away below the surface of the segments, is commonly practiced as a cure for high mica, and is so well known that little need be said about it here. However, the mica is often undercut too deeply with the result that carbon dust and dirt collects between the copper segments and may cause shorts. Trouble of this sort may be prevented by filling the space above the mica with one of the special cements or varnishes which are sold for this purpose. A cement is generally preferable, because as the cement wears out of the undercut space, the abrasive action keeps the commutator surface clean.

Manager, WM. L. WEBER.
Acme Abrasive Co.,
Chicago, Ill.

Method of Measuring Annular Pieces with a Micrometer

TROUBLE is often encountered in trying to measure accurately an annular piece of metal, because one of the jaws of the micrometer cannot make a flat contact at the exact section being measured, due to the concave surface of the piece. This difficulty can be overcome by employing a ball or round rod, as a spacer between one jaw of the micrometer and the work, to make the necessary point contact.



Using a ball or round rod in conjunction with a micrometer facilitates the measuring of annular pieces.

When using a micrometer to measure tubing, ground ball races, collars or annular pieces, either a ¼-in. steel ball or a piece of ¼-in. drill may be utilized to advantage, as shown in the illustration.

If it is desired to determine the thickness of a ball race, place a ¼-in. steel ball in the ball race and take a measurement which will include the diameter of the ball. The desired measurement is then determined by deducting ¼-in. from the micrometer reading.

In order to determine the thickness of tubing, springs and other materials when they are coiled, a ¼-in. round rod can be used to advantage in a manner similar to that employed in the use of the ball, as described in the previous paragraph. G. A. LUERS.
Washington, D. C.

Replacing Concentric Chain Winding on a Generator with Two-Layer Type

IN REPAIRING the winding of a 70-kw., 60-cycle, three-phase, 24-pole, 440-volt, 92-amp., revolving field generator, it was found advisable to replace the old concentric-chain, hand winding with one that would be less expensive and have better operating qualities.

The original winding shown at the left in the illustration, consisted of 72 hand-wound coils of three turns of No. 6 round d.c.c. wire in 144 slots, connected series-star, one coil per slot and one coil per group, arranged as a concentric chain winding with the coil ends in two ranges. The pitch of the outside coils was 1-and-8 and of the inside coils, 1-and-6, or an average pitch of 1-and-7. Full pitch equals 144 (slots) ÷ 24 (poles) = 6. Although this machine was rated at 92 amp. per terminal, it had been carrying a load of between 110 and 120 amp. constantly, until the insulation failed, because of abnormal heating.

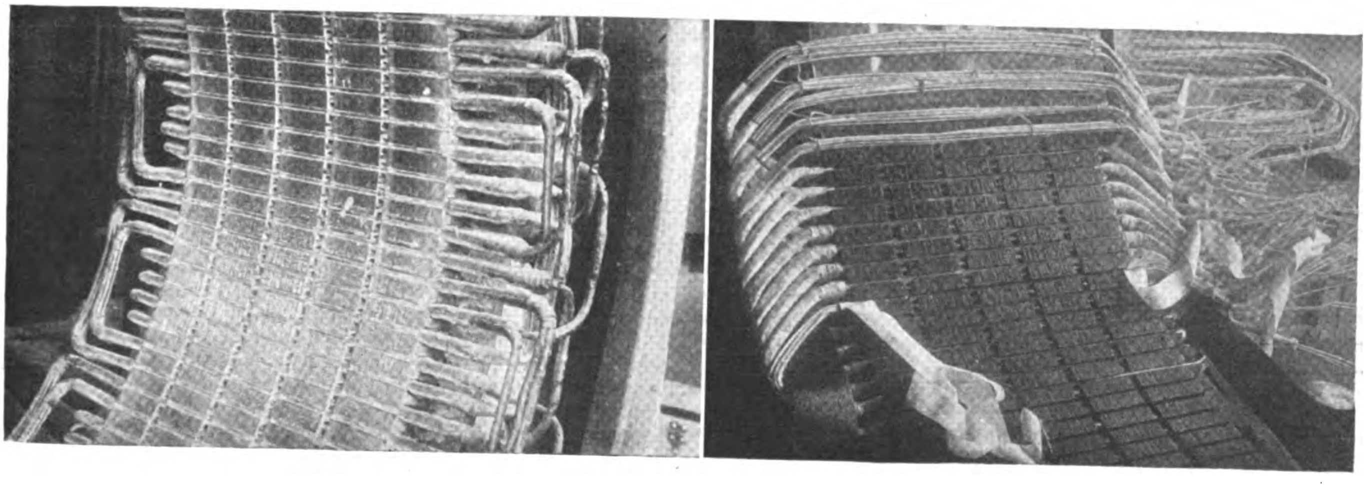
When the stator was received in the shop for rewinding, we were requested to put in all the copper possible. An inspection of the slots showed that there was more insulation between the slot conductor and ground than is required for 440 volts. This thick slot cell was used for mechanical reasons, because with this type of coil the wires are pushed through the slots one at a time until the required number of turns are in place. In the process of pushing each turn through the slot, a certain amount of insulation is peeled off, and if the cell is thin it will be punctured. There was also a 1/16-in. by ¼-in. wood filler in the bottom of the slots.

We decided to put in a two-layer, flat, diamond-shape, mush-coil winding, in place of the original concentric-chain, hand winding. Since a mush coil was required and more copper was also wanted, No. 6 wire could not be used, as it was too large to thread through the slot opening. One No. 6 wire has an area of 26,250 circ.mil and at 92 amp. this equals 26,250 ÷ 92 = 285 circ.mil per amp. Then in order to keep the same temperature rise at 120 amp. at least 120 × 285 = 34,200 circ.mil would be required.

The largest wire that would go through the slot opening easily was found to be No. 12, which has an area of 6,529 circ.mil. For the required circ.mil area, there would have to be 34,200 ÷ 6,529 = 5.24 wires in parallel. Five wires in parallel would equal 5 × 6,529 = 32,645 circ.mil, which is 1,555 circ.mil less than required. Six wires would give 6 × 6,529 = 39,174 circ.mil, and there would be 6 × 3 = 18 No. 12 wires per slot. This number of wires was tried in a slot with the required slot insulation and found to fit satisfactorily. The next problem was the number of turns per coil, as there are three turns per coil for the one-coil-per-slot winding. In order to keep the voltage the same with the two-layer, two-coil-per-slot winding, 1½ turns per coil would be required. One and one-half turns being impossible, it was decided to wind the coils with three turns of three No. 12 d.c.c. wires in parallel and connect the winding two-parallel star as this would be equivalent to three turns of six No. 12 d.c.c. wires. This winding should be good for 39,174 ÷ 285 = 137 amp. per terminal with the same temperature rise as the original winding, which is the equivalent of 49 per cent more copper.

At the right in the illustration is shown a section of the new winding with a 0.023-in., combination fishpaper and treated cloth cell used for slot insulation. This cell projected 1 in. on either side of the core; a 0.008-in., tan, treated-cloth slider was used for the top and bottom halves of the coils and a 0.023-in. fishpaper "Willie" or separator was used between the top and bottom coils in the same slot. Each coil end was taped from cell to cell as shown. One coil was taped with one half-lapped layer of 0.007-in., cotton tape, and every second coil was taped with one half-lapped layer of 0.008-in., tan, treated-cloth, bias cut, and one layer of cotton tape. This tape was extended well into the slots and after the fiber wedge was in place, the slot cell was sealed by tapping as shown in the illustration, which also shows the heavy, oiled duck between the top and bottom coil ends.

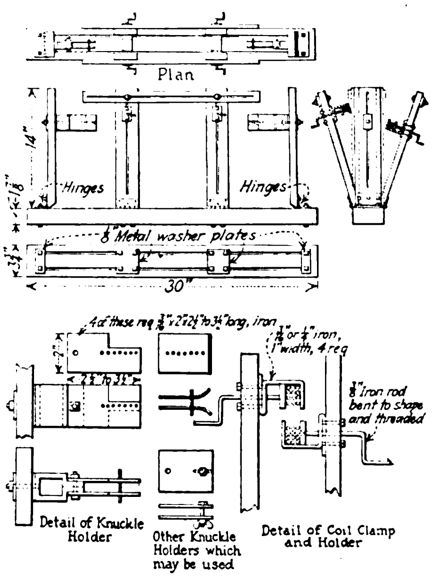
When all the coils were in and the stator connected up, it was baked for 8-hr., dipped while hot in a clear baking varnish and then baked at 215 deg. F. for 36 hr. This new winding made an up-to-date machine that will stand 120 amp. and still have an overload factor up to 150 amp. for 2 hr. at 50 deg. C. A. C. ROE.
Wilkinsburg, Pa.



This shows, left, a portion of the original concentric chain winding and, right, the two-layer, mush-coil winding that replaced it.

Inexpensive Coil Pulling and Forming Device

THE accompanying illustration shows the construction of a coil puller and former which I have found to be very useful. As will be noticed, it is made for the most part of wood,



This coil puller may be made of materials available around any repair shop, and can be adjusted to handle loops up to 24 in. in length.

which is easily worked, and the metal parts are also simple. This device could, of course, be made entirely of metal, if desired, but the cost would hardly be justified.

Most of the coils which the small or medium-sized repair shop is called upon to make can be handled satisfactorily by this device. It will pull loops up to 24 in. in length, if constructed according to the dimensions shown in the diagram. The knuckle holder arm can be adjusted to give kick up or down, as required. The loop is inserted by lowering the knuckle holder arm and pushing the loop lengthwise into the holders.

Any coil can be duplicated by putting simple stops on the arms, to limit the travel according to the size of the coil.

Although this device will not make coils so good as those produced by some of the coil formers on the market, it will produce better-shaped coils than those pulled in a vise, and will save time. ARTHUR G. WAGONER.
Brooklyn, N. Y.

Method of Removing Bar Winding from Stator of Motor

RECENTLY we received a 450-hp., 230-volt, 900-r.p.m., Ridgway squirrel-cage induction motor to be rewound. The stator winding was bar-wound, four bars per slot, wave-connected and consisted of two windings, one on top of the other, connected in series. The stator had 144 slots of the semi-closed type and the coils had been installed by pushing them through from one end of the slot.

After the end connections were removed and the top wedges taken out, we attempted to pull out several of the bars by hand, but found that they were stuck. This was due to the fact that the bars were taped with one layer of oiled linen tape and the rest of the insulation was applied in the form of a cell; the whole was then varnished. After several unsuccessful attempts, we finally pulled out one of the top bars. On attempting to remove one of the lower ones, we found them to be just as tight. We soon arrived at the conclusion that it would be a strenuous job to pull out all the bars by hand.

This difficulty was overcome by using a block and fall to do the pulling. We placed the stator so that one side of it faced one of the columns of the building. The block and fall were then tied to this column. A hand clamp was attached in turn to the end of each bar and to this clamp was tied a loop of stranded copper wire into which the block was hooked. We found that by this method one man could easily pull out the bars. MICHAEL REUTER.
Brooklyn, N. Y.

Practical Books
for your personal library

Every man who aspires to larger responsibilities should build up a professional library containing carefully selected volumes on subjects related to his work. Copies of the books which are reviewed here may be obtained from the publishers mentioned.

Mathematics for Engineers—By Raymond W. Dull. Published by McGraw-Hill Book Company, Inc., 370 Seventh Avenue, New York, N. Y. Cloth; 5½ x 8 inches; 780 pages; illustrated. Price $5.

This book is a thorough, quick and convenient reference book as well as a complete text on mathematics. It has been prepared primarily for engineers who want a quick and convenient reference, for engineers who have grown somewhat rusty in their mathematics, and for engineers who feel the need of a text for the study of mathematics.

* * * *

Alternating Currents—By Carl Edward Magnusson, Professor of Electrical Engineering and Director, Engineering Experiment Station, University of Washington. Published by McGraw-Hill Book Company, Inc., 370 Seventh Ave., New York, N. Y. Cloth; 6 x 9 inches; 611 pages; 522 illustrations. Price $5.

This book is a discussion of the fundamental principles of alternating currents, with illustrations of their application to industrial problems. It aims to give a clear concept of what actually takes place in alternating-current machinery, to explain the relations between the factors involved, and to express the physical facts in mathematical terms so that the reader can use the equations rationally in the solution of every-day industrial problems. The book has been thoroughly revised in this, the third edition, in the light of the considerable progress that has been made during the past decade in the application of alternating currents to industrial requirements.

* * * *

Standard Wiring—By H. C. Cushing, Jr. Published by H. C. Cushing, Jr., 15 West Fiftieth Street, New York, N. Y. Leather; pocket size; 464 pp.; 381 illustrations; 81 tables. Price $2.50.

In the 1926 (32d Edition) of Cushing's "Standard Wiring for Electric Light and Power" the author has endeavored to set forth the essential requirements for safe and efficient wiring and construction for electric light, heat, and power. Every suggestion and recommendation is in accordance with the 1925 National Electrical Code and the latest engineering practice. There are many explanatory and helpful notes, illustrations, definitions, and tables for the guidance of the man who does the work.

This handbook covers the subjects of inside wiring, outside wiring, generators and motors, storage batteries, illumination, and special types of wiring such as in garages, theatres, moving picture houses, electric range, heater, and radio wiring.

This well-known manual seems to become more useful and usable with each new edition. The arrangement of its material is such that all of the information required for any particular problem in interior house wiring is found where one would expect to find it. Directions are concise, clear and practical; references to authority are definite and there is little if any unnecessary text.

The book is essentially a practical man's handbook and should be a most useful companion for any wireman or electrician—one to advise when advice is wanted, and discreet enough not to bother at other times.

* * * *

American Machinists' Handbook—By Fred. H. Colvin and Frank A. Stanley. Published by McGraw-Hill Book Co., 370 Seventh Ave., New York, N. Y. 972 pp. Price $4.

This is the fourth edition of a handbook that has become the recognized standard reference book for machine shops. The book is a practical one intended for the man engaged in mechanical work of any kind, regardless of his position in the shop or drafting room.

In preparing the fourth edition of this book the problem of keeping the book from becoming too bulky for convenient use has been very difficult. Many new standards and practices have come into use since the last edition. However, as much of the new material replaces old tables, it has been possible to present much new matter without largely increasing the total number of pages.

While the size of the handbook has not been materially increased and much of the old book remains, the entire text has been very carefully revised and there is so much new material which was not formerly available, that it is a new edition in every sense of the word.

* * * *

English Applied in Technical Writing—By Clyde W. Park, Professor of English, College of Engineering and Commerce, University of Cincinnati. Published by F. S. Crofts & Co., New York, N. Y. Cloth; 5½ x 8 inches; 313 pages; illustrated. Price $2.25.

While this book is intended primarily for the student of engineering, it is well worth the perusal of any engineer or technical man desiring to improve the quality of his technical English or the character of presentation of his reports and other writings.

Although the practical kinds of writing are emphasized in this book, the subject of composition is not treated in terms of "Engineering English," or any other sort of occupational dialect. On the contrary, English is considered to be English, regardless of the subject matter with which it happens to deal. Most of the illustrations are drawn from familiar types of technical work, because the specific problems of everyday writing represent the greatest need for the use of English and the best opportunity for giving the student a working knowledge of the fundamentals of effective writing.

* * * *

Controllers for Electric Motors—By Henry Duvall James. Fellow American Institute of Electrical Engineers. Published by D. Van Nostrand Co., New York, N. Y. 522 pages, 444 illustrations. Price $5.

The present volume is the second edition of this book. The material in the first edition appeared as a series of articles in *The Electric Journal* during 1917 and 1918, and was issued in book form in 1919. Since then a part of this text has been rewritten, and considerable material added.

The introduction of the book states in detail the function of control, giving all the requirements that constitute a good controller. The different types of controllers are then classified, and the advantages and limitations of each type are given. This is followed by a chapter giving the historical developments of control, tracing the history from the earliest forms of manual control to the present, highly-specialized forms that are in common use. A chapter is devoted to the installation requirements and the Code requirements for all forms of control. Two interesting chapters discuss the methods of reading controller diagrams, and tell how to make up diagrams illustrating the wiring of controllers.

Four chapters discuss the ways of accelerating motors, the starting characteristics of motors with the different types of control, and methods of speed control and dynamic braking.

Following this are chapters giving the details of construction and application of the different forms of direct-current and alternating-current controllers. In this discussion is also included an entire chapter on the design and selection of resistors, which will be of great interest to operating men who now have trouble with the resistors under their care.

The second half of the book is devoted to controller applications, including mine hoists, pumps, machine tool applications, calendering, printing, and paper machines, steel mill applications, cranes, car dumpers, and coal and ore bridges. In addition to the foregoing, there are chapters relating to coke plant applications. elevators, oil wells, and all forms of electric locomotive applications.

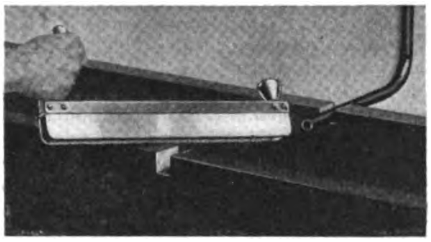
The book is well written and very easy to read, with no involved mathematical formulas. The time spent in reading it will be worth while. It should find a prominent place in everv operating man's library.

New Equipment
for plant operation and maintenance

Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these new devices which are designed to improve plant operation or reduce operating and maintenance costs.

Joist Notcher

A LABOR-SAVING device, known as the "Jiffy" joist notcher is being marketed by Paul W. Koch & Co., 33 S. Wells St., Chicago, Ill. This device is a two-bladed saw adjustable for cutting slots in joists for either ½-in. or ¾-in. conduit. This notcher makes both cuts in one operation, thereby saving



one-half the time generally consumed on this job. The tool is equipped with a depth gage which prevents excessively deep cuts being made in the joists and thus weakening them. The handles of the notcher are made of aluminum and are fitted with high-grade steel saws. The tool weighs less than 3 lb. The tool is said to be very easily operated, working on the principle of a plane.

Explosion-Proof Motor and Control

AN EXPLOSION-PROOF d.-c. motor and control, designed primarily for service in coal mines in which the presence of large quantities of gas or coal dust makes the use of electrical equipment of special construction essential to safe operation, has been developed by the Westinghouse Electric & Manufacturing Co., East Pittsburgh Pa.

Although designed particularly for small pumps, the motor which develops 5 hp. at 1,150 r.p.m., can be used on numerous other applications. The motor is of the totally-inclosed type and the brackets are provided with covers which can be removed to facilitate inspection and brush adjustments or replacements. These covers are also arranged so that they may be sealed to the brackets in order to prevent removal by unauthorized persons. All connections between the motor leads and the power supply are made inside of the motor frame. The conductor cable is brought out through a special brass stuffing box which is packed with asbestos twine, thus forming an explosion proof seal, it is stated.

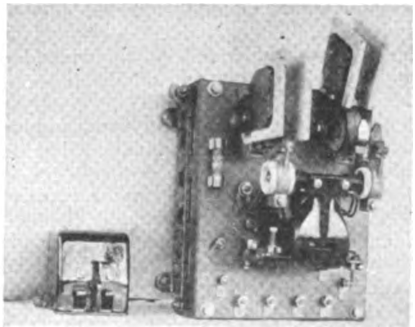
The controller is of the magnetic, push-button type, inclosed in a strong, explosion-proof case which is made in two sections. The panel on which the contactor is mounted is fastened to the lower section; the upper section fits over this panel and is fastened to the base by means of a bronze clamping ring thus eliminating the use of bolts or screws. This 5-hp. motor and control has been developed to meet the United States Bureau of Mines requirements for electrical equipment designed for use in gaseous mines, and has successfully passed these tests, according to the manufacturer.

Push-Button Magnet Controller

CONTROL panel and push-button master switch for operating electromagnets are announced by The Ohio Electric & Controller Co., 5900 Maurice Ave., Cleveland, Ohio. This equipment is shown in the accompanying illustration. The master switch (at the left) has "lift" and "drop" levers with a barrier between which projects farther than the levers, to prevent accidental operation. This master can be attached to the ceiling, to the side wall, to the top of the hoist controller, or to the throttle of a locomotive crane and operated with the thumb or finger, or placed on the floor and foot operated.

The operation, as described by the manufacturer, is as follows: The controller closes the magnet circuit for "lift" and when the master is thrown to "off" the magnet circuit is open for "drop" but permanently connected across the magnet terminal is an ironclad, protective resistance which, it is said, converts the inductive kick into heat through a resistance. For a quick drop or for handling high-carbon materials, the master handle is pushed through or the bottom lever of the "push-the-button" master is pressed and a limited reverse current is applied to the magnet, which causes the magnetism to drop to zero and the load to drop promptly.

The resistance element consists of five strips of armored Chromalox. The control panel is fused to protect against grounds or short-circuits.

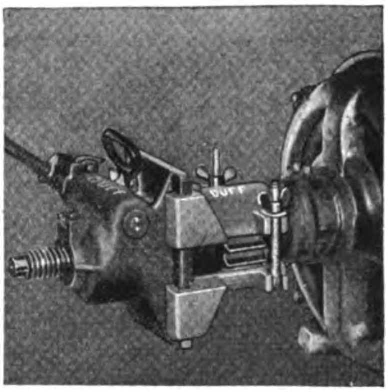


Pinion Puller

THE pinion puller shown in the accompanying illustration, which is for use in electrical and industrial mechanical and repair departments and railway shops, has been placed on the market by the Duff Mfg. Co., Pittsburgh, Pa.

The puller consists essentially of clamping jaws and a screw jack. The jaws are of a thin-lipped design and are intended to fit over the pinion. The screw-jack section slides into the jaw section. When the jaws are attached, the operator turns up the screw until it makes contact with the shaft of the motor. A few strokes of the lever are claimed to bring the device into full tension and further operation removes the pinion.

Three sizes of jaws are available for various sizes of pinions, pulleys, or



small flywheels. The housing and the jaws are made from case hardened steel, and ball bearings are used throughout. According to the manufacturer a uniform force is exerted around the circumference of the pinion. The overall weight of this particular pinion puller is 50 lb.

Direct-Current Relays

ANNOUNCEMENT is made of a new line of d.c. relays, known as the type SR, by the Roller-Smith Co., 233 Broadway, New York, N. Y., which will supersede its old relays known as the Imperial type.

In these new relays, according to the manufacturer, the scales are longer, the accuracy is greater, the torque has been increased several times, and the new 7½-in., round-pattern style of case has been adopted to match the company's type SA and type SD lines of indicating instruments.

In these relays regular instrument mechanisms are used for operating the self-contained, circuit-opening or closing switch. The instrument mechanism has a platinum spring contact attached to its pointer, which contact co-operates with a similar one carried by an externally-adjustable, pilot needle. The pilot needle is set by means of a slotted-head button projecting from the front of the relay case. The circuit established on the engagement of the contacts, energizes an electromagnet which is mounted below on the same base with the instrument; the switch operated by the electromagnet then

effects whatever external circuit change the relay is designed for.

These various forms of relays, while they can be used for many special applications, are designed primarily for use with the company's undervoltage and shunt-trip types of circuit breakers. The relays are available in the following forms: Reverse current, overload, underload, closed circuit underload, overvoltage and undervoltage. The company states that it is also prepared to furnish any special relays desired.

Portable Voltmeter and Ammeter

A NEW combination ammeter and voltmeter, which is known as the Martindale Universal Portable Ammeter and Voltmeter, has been put on the market by The Martindale Electric Co., Cleveland, Ohio.

This set consists of a separate voltmeter and ammeter mounted together in the same case, in which space is also provided for five ammeter shunts, rated at 5, 10, 50, 100 and 300 amp., respectively. The voltmeter has an internal resistance of such value that full scale may be 75, 150, 300, or 600 volts, depending upon which binding posts are used.

The meters can be used on either direct current or alternating current. This instrument is so constructed that either meter may be removed from the case and used separately when desired.

Universal Trouble Shooter

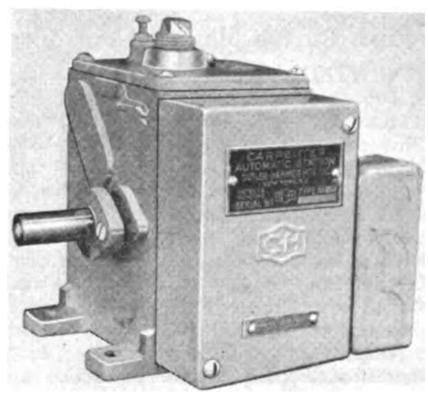
MARKETING of the trouble shooter, which is shown in the accompanying illustration, for use in locating grounds, open and short-circuits and other electrical troubles, has been announced by the Universal Test Equipment Co., 2929 N. Oakley Ave., Chicago, Ill.

This device consists of a pair of testing handles made of Thermoplex, which is claimed to be heat- and shock-proof, lead wires, and a special separable socket and plug. The handles have removed caps so that different sizes and lengths of lead wires can be inserted. Two 5-ft. leads, which are held together with four pure gum sleeves that can be adjusted to suit the range desired, are furnished. Pointed steel rods are used to make contact.

This plug, it is stated, fits any standard a.c. or d.c. lamp socket and the separable socket is standard for holding any size of test lamp. Ordinarily the test lamp is in series with the test handles so that the lamp lights when the circuit is completed, but a spring contact is furnished which makes it possible to place the lamp in parallel for use in testing live circuits.

Automatic Acceleration and Braking for A. C. Motors

A NEW device for automatically controlling the acceleration and braking of a.c. motor-driven equipment has been developed and placed on the market by The Cutler-Hammer Mfg. Co., Milwaukee, Wis. This device, which is shown in the accompanying illustration is called the Carpenter Automatic Control Station and has been applied extensively to printing equipment, although its field of application extends



to numerous other types of motor-driven machinery on which it is desirable to control the speed of acceleration. and produce a braking effect.

The station is used in connection with the standard types of automatic push-button-operated, magnetic controllers which are employed with slip-ring motors, although it can also be used with controllers for squirrel-cage motors. The operation, according to the manufacturer is as follows: When the "run" button is depressed, the device functions to keep the external resistance in circuit (thereby limiting the current inrush) until the motor has attained 40 per cent of normal running speed, at which time it automatically opens the torque switch, shunting out the external resistance, and closes the run switch for normal operation of the motor.

When the "stop" button is depressed the device functions to open the line switch, which opens the run switch through an interlock. At the same time it closes a reverse line magnetic switch with the external resistance in circuit, thus creating a field in direct opposition of rotation and exerting a braking effect equal to the rated torque of the motor. Just before the motor comes to dead rest the reverse switch circuit is opened, thus compensating for the switch leg. The motor is stopped without any possibility of reversing or coasting.

Essentially, the Carpenter Automatic Station consists of an oil pump which operates a contact-making device. The pump is belt-connected to the driven machine, and when the speed of latter reaches 40 per cent of normal running speed, the pressure generated by the pump, it is stated, serves to operate a contactor which opens the torque switch and closes the run switch and so automatically prevents the motor from being switched directly on the line until it has attained 40 per cent of normal running speed.

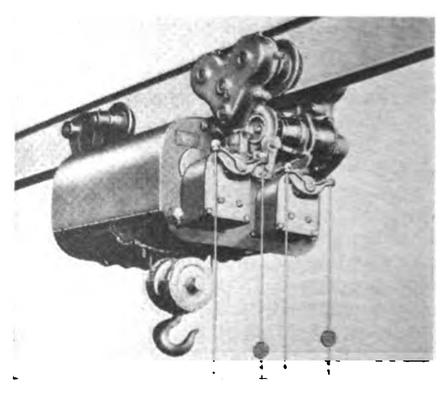
When stopping the motor, depressing the "stop" button instantly closes the reverse torque switch, it is stated, and when the pump pressure decreases to an adjustable value, the reverse torque switch is opened, so that the motor comes to rest quickly. The range of machine speeds for which the pump is regularly furnished is 60 to 300 r.p.m., although it can be adapted for speeds up to 1,800 r.p.m. or even higher. The manufacturer also states that the Carpenter Automatic Control Station can be used to perform other functions in connection with auxiliary attachments, such as operating gas valves, with unloading devices on air compressors, and with various other equipment where special control is needed.

New Electric Hoists

ADDITION of six new members to its line of Lo-Hed electric hoists is announced by the American Engineering Co., Philadelphia, Pa. These new hoists range in capacity from 3 to 12 tons and are made for bolt suspension, hand-geared trolley, motor trolley, and cab control; either open or closed cabs are available. Remote control can be arranged when desired.

These hoists, one of which is shown in an accompanying illustration, are designated as Class J and embody the same principles of design, according to the manufacturer, that characterize other models of Lo-Hed hoists, with such additional features as are made necessary by the higher speeds at which they operate and the heavier loads they are designed to handle. Rated capacities are 3, 5, 6, 8, 10 and 12 tons, so that the Lo-Hed line now includes hoists from ½ ton to 12 tons capacity which range will take care of a very large number of installations.

The hoist operates, it is stated, on standard I-beams, through switches and around curves. Hyatt roller bearings



are used on the trolley wheels and ball thrust bearings between the wheels and the trolley frames. The trolley trucks are swiveled for curves of short radius.

The ball-bearing hoisting motor is totally enclosed and drives the drum by spur gears running in oil. Hyatt bearings are provided on the ends of the shafts. The working parts are accessible for inspection and care by simply removing the cover of the hoists, the manufacturer states; also, the motor and pinion can be removed as a unit without taking off the gear cover or draining the oil from the gears. Safety features, it is stated, include a factor of safety of five in the design of the hoist; upper limit stop; and a powerful, quick-acting brake that is automatically applied the moment the current is turned off, either accidentally or intentionally, and stops all movement of the load without drift.

Cupola Charger on Electric Truck

THE accompanying illustration shows a crane type of electric truck designed by the Baker-Rauling Co., Cleveland, Ohio, for cupola charging. This

machine operates in connection with Chisholm & Moore 1-ton charging buckets and makes use of the Morgan patented bucket yoke.

The truck, it is stated, is assembled principally of standard Baker parts; that is, the axles, controller, automatic switch, hoist, hoist controller, limit switch, and so on, are inter-standardized with all other models of Baker trucks and tractors. The motors receive power from a 48-volt storage battery contained in the large steel box near the driver's end of the truck.

The Morgan charging bucket is circular in shape with a conical bottom. In operation, the bucket is loaded and picked up by means of an eye fastened to the center of the bottom. When the bucket is raised the four dogs on the yoke engage with the angle-iron ring around the top. To discharge the bucket, it is necessary only to reverse the power on the hoist. This lowers the bottom while the shell is held up by the yoke. Because of the conical shape of the bottom the charge is spread evenly around the cupola. To place the bucket back on the floor the bottom is raised until it engages the shell and raises the ring clear of the dogs. The dogs are then held clear of the ring by means of the chain leading back to the operator's position while the bucket is being lowered.

The upward travel of the hoist is limited by an automatic safety switch which cuts off the power when the bucket has been raised so that the ring is 1 in. above the dogs.

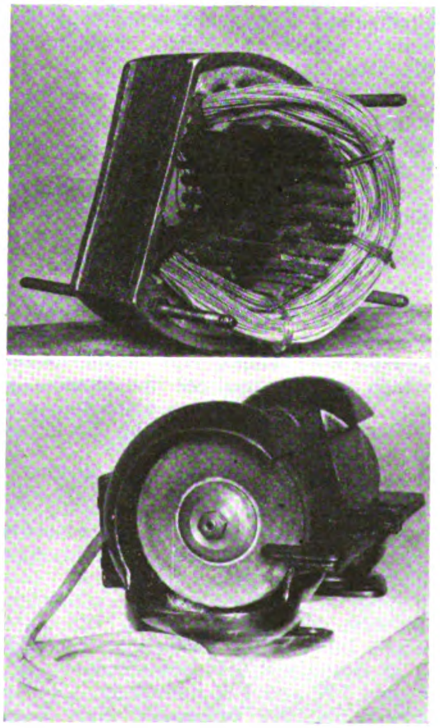
The boom is strengthened with a steel plate on the side toward the fire. This keeps the heat away from the cable and the hoist sheaves.

Electric Tool Grinder

MODEL 75 electric tool grinder, which is shown in the accompanying illustration, is designed for use on electric light sockets with 110- or 220-volt a.c. current. The manufacturers, Forbes & Myers, 172 Union St., Worcester, Mass., state that the $\frac{1}{2}$-hp. fully enclosed motor has no brushes, commutator, centrifugal device, or clutch, and believe that this grinder will be as free from troubles as three-phase motors for power circuits. The grinder motor is of the flat-front type introduced by this company four years ago. The construction is also shown herewith. It is stated that the flat is but $1\frac{5}{8}$ in. from the center of the shaft, which will permit a 6-in. wheel to project well in front of the motor.

The construction and operation, as described by the manufacturers, is as follows: The rotor, the only moving part, is of the simple, squirrel-cage induction type used on three-phase motors and consists of an iron core on a steel shaft. Slots through the core are filled with aluminum bars. The bars at each end are welded together by the acetylene torch into solid aluminum rings.

The stator is of the laminated type with slots for the winding, but it differs from the usual construction in that there are no wires at the front. The main coil, of heavy wire, extending from top to bottom, receives its current directly from the line. An auxiliary winding of more turns of fine wire, extending but half the distance, receives its current from a condenser mounted at the rear of the motor. Both windings are in use continuously and, it is stated, both deliver their share of the power. The shaft is mounted on ball bearings.

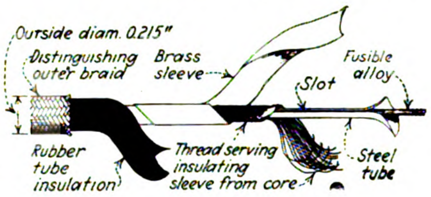


Self-Lubricating, Non-Metallic Gear Material

ANNOUNCEMENT has been made by the Fibroc Insulation Co., Valparaiso, Ind., that a new self-lubricating Bakelite gear material known as Fibroc GR is now being marketed. This is a Bakelite product which is impregnated with graphite. The manufacturer states that for this reason gear teeth made from this material are self-lubricated, and estimates an increase of gear life of 35 per cent. Fibroc GR can, it is stated, be cut and formed into gears the same as other Bakelite materials and has the same quality of noiseless operation that is characteristic of non-metallic gears.

Fire-Detecting System

A FIRE-DETECTING system using a special automatic continuous thermostatic wire has been placed on the market by the Garrison Fire Detecting System, Inc., 79 Madison Avenue, New York City. The wire, as shown in the accompanying illustration, is of the concentric type. The inner



wire consists of a fusible alloy protected by a steel tube having a lateral slot. When the temperature of the wire is raised the alloy melts, expands, and spurts through the slot in the steel tube, permeating the insulating threads between the conductors and contacts with the brass sleeve or outer conductor, thus closing a circuit, and giving an alarm.

To insure that the system is in perfect working order at all times, a minute current is continuously circulated through the fusible alloy and the brass sleeve. Interruption of this current causes a relay to function giving an alarm.

It is claimed that this fire detecting system is adaptable to meet every requirement from the small dwelling to the largest industrial plant. It is not dependent on any outside source of power as it utilizes a double set of storage batteries for its operation, which batteries are also under supervision. All the component parts of the system are made by well-known manufacturers. For instance, the special fire-detecting wire is made by the Okonite Company, the batteries by the Electric Storage Battery Company, the relays by the Western Electric Company, the panels by the Bakelite Corporation; the gongs, transmitters and contactors are made by the Samson Electric Company, and the meters by the Weston Electrical Intrument Corporation. The Garrison fire-detecting system has been approved by the laboratories of the National Board of Fire Underwriters and Associated Factory Mutuals.

Trade Literature

you should know about

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Rheostats—A new bulletin, 1140, describes and illustrates the Jagabi Rheostat.—James G. Biddle, 1211 Arch St., Philadelphia, Pa.

Blower Systems—Many types of collecting, ventilating, and conveying blower systems are described and illustrated in a new catalog.—The Kirk & Blum Mfg. Co., Cincinnati, Ohio.

Cartridge Type Heaters — Circular GEA-104 illustrates applications of the G-E cartridge type heating unit and lists dimensions and ratings.—General Electric Co., Schenectady, N. Y.

Resistors—Bulletin 104 gives the sizes, ratings and list prices of the standard banks of Monitor Edgewound resistors.—The Clark Controller Co., 1146 E. 152nd St., Cleveland, Ohio.

Motors and Fans—"The Emerson Monthly" discusses various applications of Emerson motors and fans for industrial and other purposes.—The Emerson Electric Mfg. Co., 2012-32 Washington Ave., St. Louis, Mo.

Carbon Brushes — Many different types of carbon brushes are illustrated and described in catalogue 16, which also gives price lists and useful data relating to the physical properties of carbon brushes.—The Ohio Carbon Co., Cleveland, Ohio.

Portable Electric Machinery—A 16-page booklet entitled, "Taking the Tool to the Work," is devoted entirely to illustrations of miscellaneous applications of Haskins flexible shafting equipment in a variety of industries.—R. G. Haskins Co., 3450 W. Lake St., Chicago, Ill.

Variable-Speed Transmission—Pamphlet T-4045 describes and illustrates a complete, self-contained, compact transmission unit which includes an electric motor. Any speed between fastest and slowest, over a range as high as 16 : 1 ratio can be obtained.—Reeves Pulley Co., Columbus, Ind.

Portable Pipe Threading Machines—A 12-page catalog illustrates the various features of construction and operation of the new Red-E Hall portable pipe threading machine with a capacity of ¼- to 2-in. pipe and with a universal-shaft drive for hand stocks up to and including 12 in. — Hall-Will, Inc., Erie, Pa.

Speed Reducers — Bulletin 251 describes the B, T and V types which are adapted for speed reductions up to 3,000: 1 and above. Bulletin 261 illustrates and describes the principle features embodied in the construction of the H. & S. worm gear speed reducers. Bulletin 263 describes the Type WV speed reducer used for vertical drives.—The Horsburgh & Scott Co., Cleveland, Ohio.

Roller Bearings—Bulletin 1560 contains descriptions and illustrations of bearing applications on general types of industrial equipment.—Hyatt Roller Bearing Co., Newark, N. J.

Lubrication of Electric Cranes and Hoists.—A very interesting bulletin describes and illustrates by phanton views how Shepard electric cranes and hoists are lubricated.—Shepard Electric Crane & Hoist Co., Montour Falls, N. Y.

Watt-Hour Meter—A well-illustrated circular, C-1753, points out the advantages inherent in the design of the new Westinghouse watt-hour meters.—Westinghouse Elec. & Mfg. Co., Pittsburgh, Pa.

Helical Gears—A leaflet illustrates and describes how helical gears are applied for low ratios of speed transformation in connection with standard electric motors.—De Laval Steam Turbine Co., Trenton, N. J.

Welding and Cutting—The line of welding and cutting apparatus is well illustrated and described in catalog No. 6. A complete price list of the equipment described in this catalog, is given in a separate circular. — Purox Co., Denver, Colo.

Machinery—A leaflet has recently been prepared which gives a full list of Farrel products. A pocket-size catalog which has also been released, illustrates many different types of Farrel machines.—Farrel Foundry & Machine Co., Ansonia, Conn.

Worm Reduction Gear—A leaflet entitled "De Laval Worm Reduction Gear with Pressure Oiling System" shows numerous applications of reduction gears, and also describes and illustrates the type of reduction gear that has a pressure oiling system.—De Laval Steam Turbine Co., Trenton, N. J.

Right-Angle Drive — A 36-page, pocket-size catalog lists and prices the various worm, bevel, miter, and spiral gears for obtaining right-angle drives, which are standardized and stocked by this company for immediate delivery.—Boston Gear Works Sales Co., Norfolk Downs, Mass.

Meters—Bulletin 110 describes new Type HTD ammeters, voltmeters and volt-ammeters. The HTA instruments, described in Bulletin 150, include alternating-current ammeters, voltmeters and single-phase wattmeters. Bulletin 550 describes and illustrates a new line of Type SR relays. On page 3 of Bulletin 810 is described the new Types TW and FW ammeters.—Roller-Smith Co., 233 Broadway, New York, N. Y.

Electric Tools—Catalog 23 describes, and illustrates, a large variety of electric drills, grinders and buffers.—The U. S. Electrical Tool Co., Cincinnati, Ohio.

Chain Drive—Catalog 812 illustrates various applications of silent chain drives for machine tools.—Link-Belt Co., 910 So. Michigan Ave., Chicago, Ill.

Acetylene Welding—A monthly house organ entitled, "Smith-O-Grams," contains interesting information on acetylene welding and cutting.—Smith Welding Equipment Corp., Minneapolis, Minn.

High-Speed Fans—Bulletin 7003 illustrates the construction, shows characteristic operating and efficiency curves, and gives capacity tables of the American class 15M, high-speed, double-inlet fan.—American Blower Co., Detroit, Mich.

Distribution Transformer — Leaflet L 20288 describes a very rugged type of distribution transformer recently developed for use on electrically-operated shovels, where vibration is excessive and transformers are subjected to inclination. — Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

Silent Chain—A 76-page catalog illustrates a number of applications of Whitney silent type chains for power transmission, discusses the advantages claimed, describes the construction and installation, and contains a number of pages of engineering data to facilitate the selection.—The Whitney Mfg. Co., Hartford, Conn.

Conduit Fittings—Bulletin 2087 describes type OCB Condulet branch extensions. Bulletin 2091 pertains to vaporproof, safety switch condulets. Folder 38 describes safety plugs, receptacles, switches and hand lamps. Folder 42 illustrates various uses for vaporproof condulets. — Crouse-Hinds Co., Syracuse, N. Y.

Variable-Speed Transmission — A folder describes the JFS variable speed transmission which is a totally-enclosed mechanical roller bearing through which a variable ratio of speed is obtained between the elements of the bearing by shifting the contact points of the races upon which the conical rollers operate.—Columbia Vari-Speed Co., 4020 W. Lake St., Chicago, Ill.

Optical Pyrometer — Bulletin 293 shows the construction and discusses the operation of the HK (Holborn-Kurlbaum) optical pyrometer. The applications, method of making determinations and corrections for various operations in different industries are given in tabular form.—Bacharach Industrial Instrument Co., 7000 Bennett St., Pittsburgh, Pa.

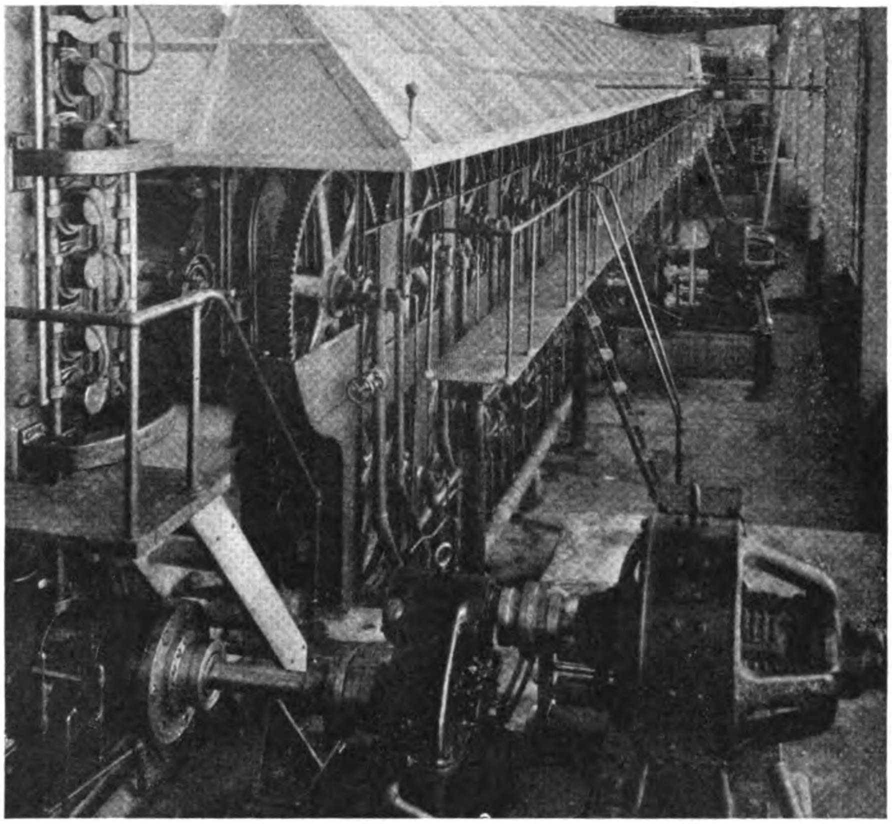
Variable-Speed Gear — Bulletin No. 108 describes the Universal Hydraulic Variable Speed Gear manufactured by this company, which is designed to be used for transmitting rotary power at variable speed in either direction from zero up to the maximum designed speed. This gear is made in five sizes, with working capacities of 15, 30, 50, 100 and 200 hp.—The Waterbury Tool Co., Waterbury, Conn.

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Volume 84 New York, December, 1926 *Number 12*

This high-speed paper machine is equipped with a train of alternate non-metallic and cast-iron gears.



Each non-metallic gear is 6 ft. in diameter and the teeth are made in sections mounted on a metal spider

Using Non-Metallic Gear Drives

TO PREVENT NOISE

by eliminating the metal-to-metal tooth contacts and also

TO REDUCE GEAR WEAR

By FRANK E. GOODING
Associate Editor, Industrial Engineer

GEAR drives, particularly after they become worn or when they are improperly installed, often become noisy. Gear noises are particularly objectionable in that they are usually of a high pitch, which is very disagreeable when near offices or around women employees. Nervous or high-strung employees are affected by the high pitch and the resultant tension has been held as a contributary cause of many accidents. As gears wear they become noisy and wear more rapidly, which further increases the noise. This also decreases the effectiveness of the gear. With excessive wear comes increased vibration which creates undesirable operation.

While there is a natural wear on all metallic surfaces rubbing on each other, such as gear teeth, excessive wear and noise frequently are due to misalignment or improperly fitted gears. If the trouble is due to misalignment, the teeth will show uneven wear; that is, one end of the tooth will be worn more than the other. As a result part of the tooth is doing all the work and receiving all the wear, which under normal conditions should be distributed evenly over the length of the tooth. In such a case it is but natural that the wear will be very rapid, and trouble and noise begin.

If the teeth mesh too tightly into each other, the driving tooth rubs not only on the driven tooth but also on the next tooth. This action destroys the tooth contour and requires an excessive amount of power until the teeth are worn down so they no longer rub on both sides. Worn teeth always permit backlash,

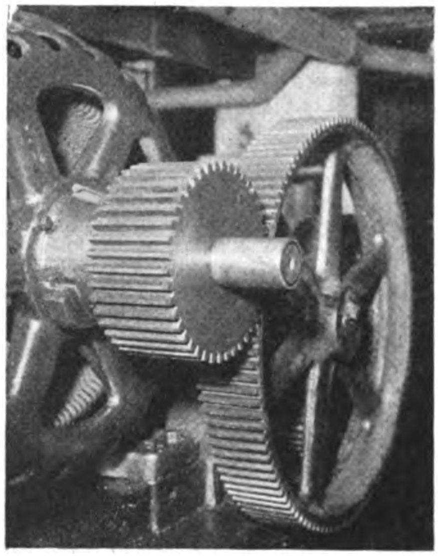
which results in noisy and irregular operation.

Where teeth do not mesh into each other far enough the load is carried on the ends of the teeth instead of on the pitch circle. This also results in uneven wear, with noise almost from the first when metallic gears are used, and considerable vibration which is undesirable from an operating standpoint.

When operating men find a metallic gear drive which wears excessively or becomes noisy rapidly, they should make a careful investigation of the alignment of the shaft and the meshing of the teeth. Correcting improper operating conditions will prevent a large proportion of the unusual wear of gear teeth and decrease the resultant noise of operation. These conditions should be remedied before non-metallic gears are installed or excessive wear will result, although perhaps not as quickly as before, even though the noise is not so obvious.

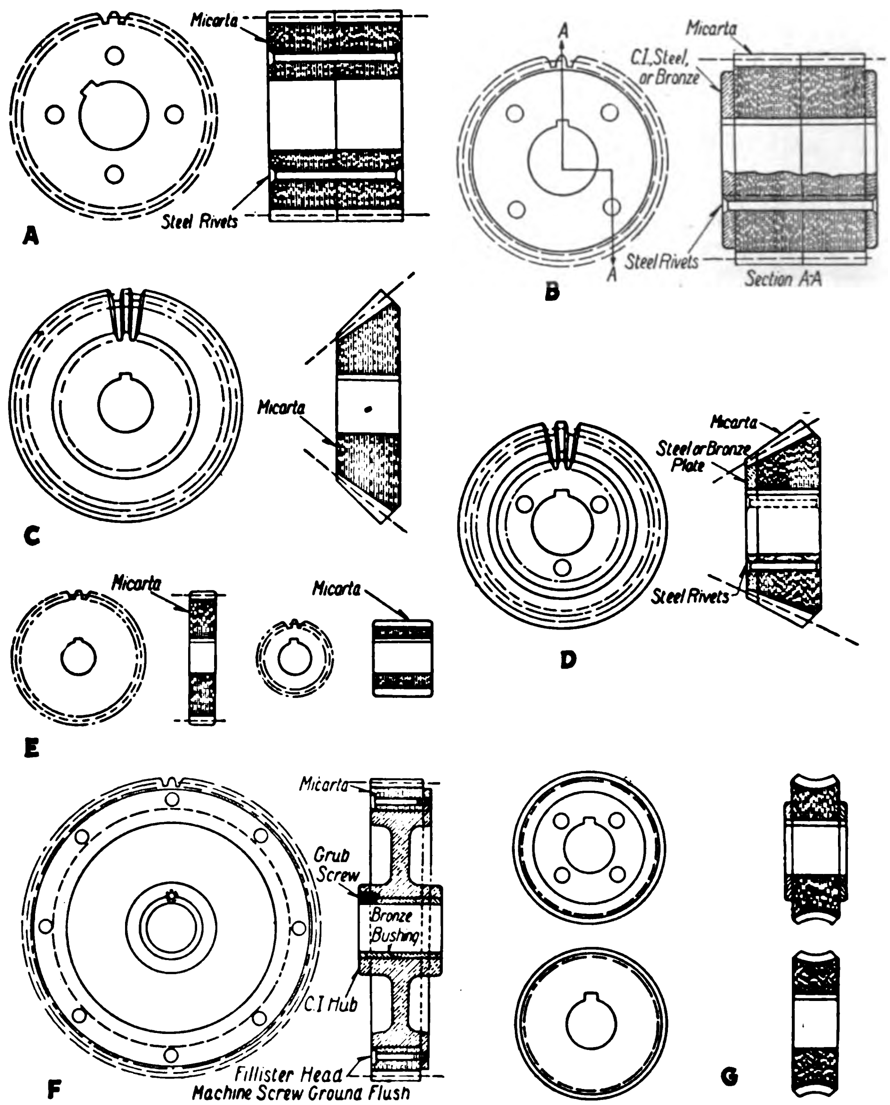
In studying the wear of gears, it has been found that less wear occurs if the meshing gears are not of the same hardness, which usually means that they should be of different material. This does not always mean that the pinion should be of a softer material, as hardened, alloy-steel pinions are used with a great deal of success in many industries where they are subjected to excessive wear. For silent gears, however, a non-metallic material softer than cast iron or steel (the materials from which gears are commonly made) is usually used. These non-metallic gears and gear materials will be discussed at length in this article.

It has been found that it is necessary to change the material in only one gear. As the pinion is the smaller, it is usually made of one of the substitute materials, all of which are more expensive than cast iron or steel. Of the non-metallic gear materials rawhide has been used the longest for industrial power transmission. Within the past few years a Bakelite-fabric product manufactured under various trade names, and a treated fabric product, both of which will be described later, have been used extensively.



This non-metallic pinion on a 100-hp. motor drives a high-pressure pump.

In the manufacture of rawhide for gears steer and bull hides as well as the hide of the water buffalo of the Orient are used. Cow and calf hides are not suitable. These hides are dehaired and cleaned, then stretched and dried until they are hard and bonelike. The dried sides, as they are called, are somewhat thinner than the green hide and in drying are not "plumped" or thickened in the process by using a filler, as is possible when tanning a hide. Gear blanks which would be made from thickened hide do not contain as many layers per inch of width; consequently the life and strain-resisting qualities are considerably reduced. Rawhide can be made no stronger than the original fiber of the green hide. This strength is retained by proper curing. After the hides have been cured, they are cut



Some of the types of standard construction which have been recommended and generally adopted for non-metallic gear and pinion construction.

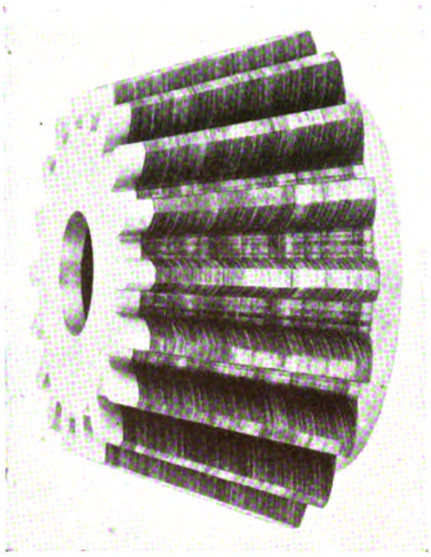
These sketches were prepared by the Westinghouse Electric & Mfg. Co., in connection with their Micarta gear material. The suggestions, however, are practically standard for all non-metallic Bakelite materials where the gear blank is cut from the board. *A*—Standard construction for riveted gear blank. *B*—Standard construction of pinion with endplate to give added hub strength. *C*—Non-metallic bevel gear. *D*—Non-metallic bevel gear with endplates to support keyway. *E*—Examples of standard construction for small pinions. *F*—Method of constructing large gears with metal hub and center and non-metallic material bolted to a flanged rim. *G*—Non-metallic worm gears with and without endplates.

into disks which are assembled in layers and cemented together to form blanks. The rough blanks are placed in a drying room which is kept at a fixed temperature. This drying process continues from two to three months, depending upon the size and thickness of the blank.

Before cutting the teeth in the gear blank, a metallic endplate, commonly of brass, is bolted or riveted through the blank. This endplate serves two purposes: First, it holds the ends of the teeth in shape and also provides a more substantial material for cutting the keyway in the pinion. For very quiet operation, it is desirable that this endplate be outside of the mesh of the gear and its pinion; that is, that no driving be done by the metallic portion.

Rawhide pinions will serve almost any class of machinery where a positive, quiet drive is an essential factor. They must be correctly aligned and properly made if satisfactory operation and long life are to be expected. However, their noiseless feature does not terminate even when they are badly worn. Also, their elasticity reduces vibration and prolongs the life of the mated metal gear. These qualities are common to all non-metallic gearing.

The manufacturers do not ordinarily recommend the use of rawhide pinions on machinery where they are applied directly to the transmission of severe reciprocating or intermittent motion, or in connection with cast gears. Cast gears are irregular and the rough gear teeth will wear the pinion excessively.



Construction of a rawhide bevel gear.

Rawhide gears are made up of layers of dried and seasoned hide, held together by endplates which are commonly made of brass.

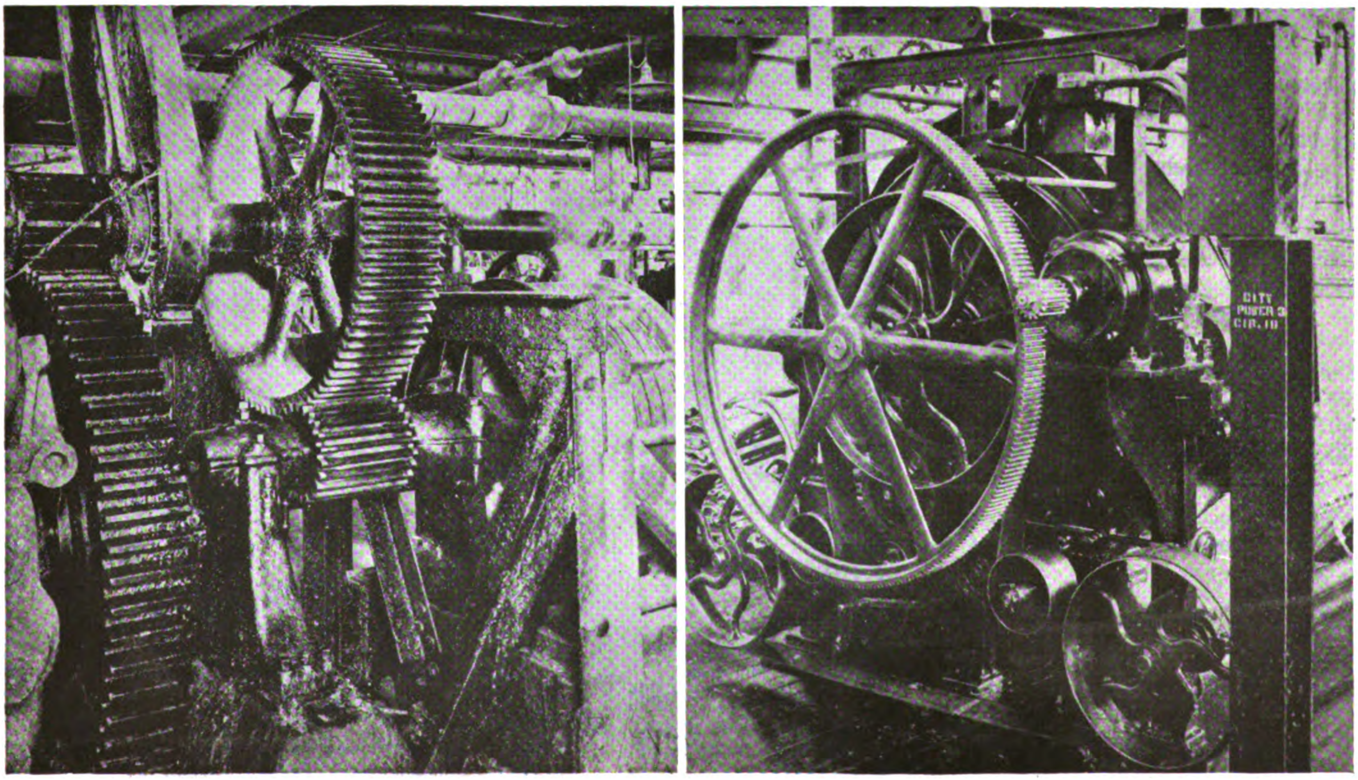
Reversing under load or reciprocating and intermittent loads, require that extra large allowances be made in the gear teeth to take care of this extra load, because such loads cause a continual bending action which is not desirable for rawhide.

The rawhide pinion will stand considerable variation of temperature from extreme hot and dry to moist. Cold has no effect on rawhide, but it is not advisable to use rawhide pinions or any other non-metallic gear in an installation where the temperature is over about 200 deg. F. Also, rawhide pinions are not recommended for use where they will be continuously subjected to water or to a bath of oil. Rawhide pinions will stand occasional water and the amount of oil usually encountered on motor-driven machines, but if they are allowed to stand in water or oil the teeth will warp and lose their shape. When storing rawhide gears they must be protected from heat and moisture.

In rating the capacity it is estimated that a rawhide pinion will carry from 75 per cent to an equal load and the same strain as a cast-iron pinion of the same size and pitch of tooth. The non-metallic pinion does not have the breaking strength of steel, and often where the load is irregular and gears are subjected to vibration, the rawhide pinion will stand up better than the metal pinion because of its elasticity and the resulting ability to give un-

Each of these motor pinions is made of impregnated cotton fiber. compressed and bolted together between endplates under high pressure.

Where very quiet operation is desired. the endplates do not touch the metal gear; this makes the pinion wider than the gear. For ordinary operation the pinion and gear are of the same width. The illustration at the left shows a pinion drive to a double rubber sheeting mill. The pinion drive at the right is on a napping machine in a textile mill.

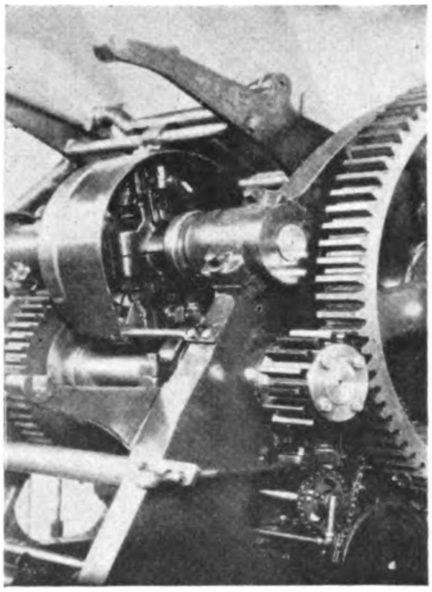


der an abnormal or unusual stress.

Manufacturers do not recommend the construction of a pinion with a hub and setscrew attached to one side of the flange or endplate because this throws an uneven strain on the rivets or studs holding the pinion together. Helical or herringbone rawhide pinions are not recommended for heavy service. They operate satisfactorily, however, on light, high-speed duty at a recommended angularity of from 15 to 20 deg., which gives continuous tooth action and avoids vibration. A pinion should not be made so small that there is not room for inserting the rivets to hold the layers of rawhide together. Steel or cast-iron endplates may be used on rawhide pinions, although this involves an extra cost over the brass endplates which are cut through to conform to shape of the teeth. Rawhide gears of extra large diameter are usually made by building up a rawhide face on a cast-iron spider. This decreases the amount of rawhide required and so makes them less expensive.

During recent years, considerable attention has been given to the use of chemically-prepared, non-metallic gear materials which consist generally of layers of fabric impregnated with and incorporated in, under heat and pressure, a body of Bakelite phenol resinoid. These materials are prepared by several companies under license of the Bakelite patents and are distributed under different, well-known trade names, such as Celoron, Contex, Fibroc, Formica, Micarta, Textolite, and others. Although all of these are made under the same basic patent which covers the method of impregnation, the fabric used and the method of handling and assembling differ to some extent among the different manufacturers. In every case Bakelite resinoid is the essential ingredient of the laminated material.

In the manufacture of these laminated, non-metallic materials, the initial resinoid is first dissolved in a suitable solvent to form a varnish. This varnish is used to impregnate

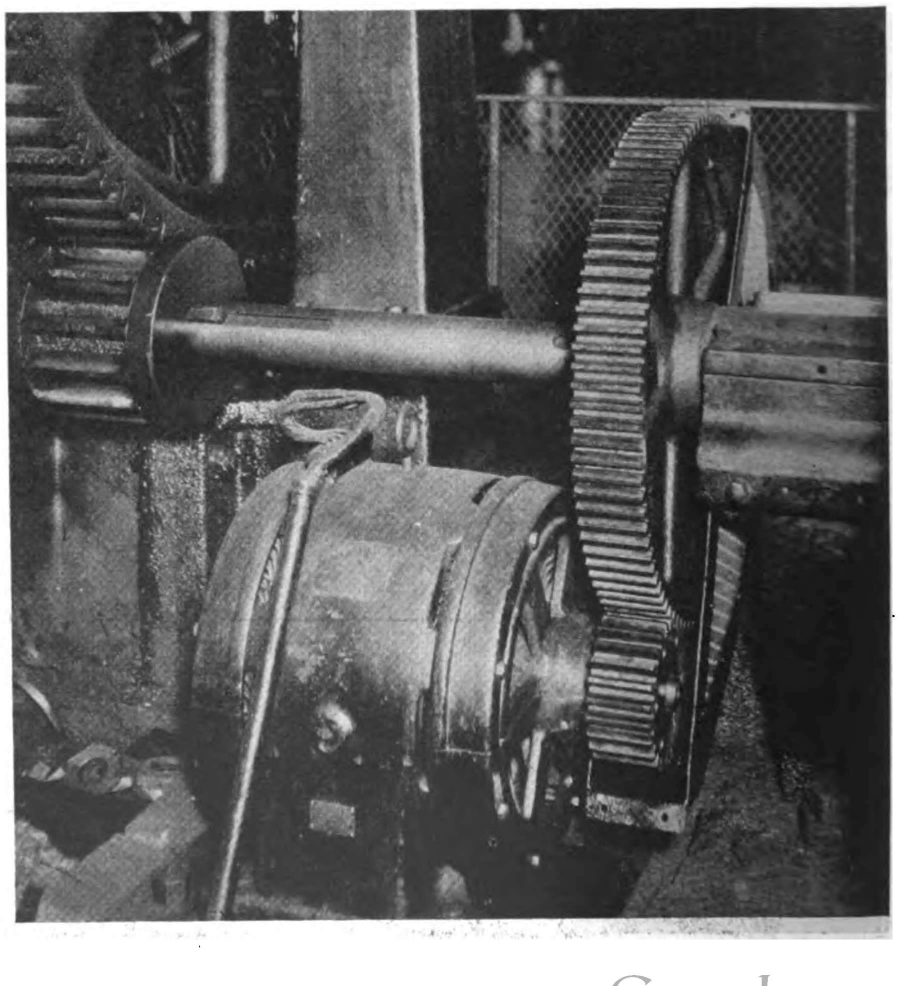


Extra small pinions of non-metallic materials require special construction to give them the necessary strength.

the laminating fabric which is usually linen or canvas. The impregnating is done on machines through which the fabric is made to pass slowly. By a combination of rollers it is made to pass through a dip tank or other device by which the varnish is continuously applied until the fabric is uniformly coated and impregnated throughout. The varnish-laden fabric then passes through a drier for evaporating the solvents. When dried, the material is cut into prescribed dimensions and a number of such sheets are superimposed and put under heat and pressure. The resultant product is a hard, rigid plate or board.

Under the correct conditions of temperature and pressure, this mass of Bakelite-laden layers of fabric is completely transformed into a uniform board, which it is stated cannot be resoftened by heat, is not affected by water or oil, and only by comparatively few chemicals, possesses good dielectric properties, and has considerable mechanical strength, but is easily machined.

The method of building up the gear blanks from this laminated material differs somewhat among the various manufacturers. The more common methods used are as follows: The first and perhaps the most common method, is to cut the blanks from laminated board of a thickness equal to the gear face. These boards are put out by different manufacturers in sizes that vary somewhat but are approximately 40 x 40 in., and of different thicknesses. The



This 10-hp. motor drives a boring mill through a Bakelite laminated pinion.

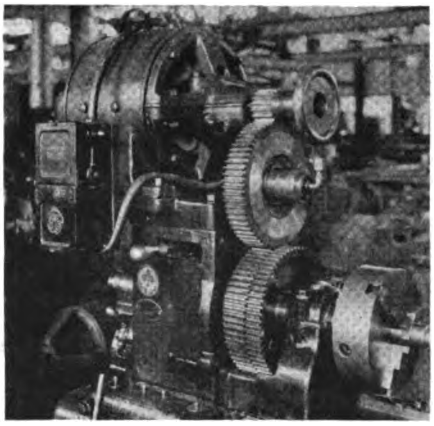
Here the high-speed motor pinion is made of a non-metallic, noiseless gear material while the slower speed pinion in the backgear driving the mill is made of cast iron with shrouds. The manufacturers never recommend the use of non-metallic pinions or gears driving in contact with cast gear teeth because of the latter's irregularity and rough surfaces which cut the non-metallic material.

blank is a single piece of material and may be cut out from the original board with a band saw or by other means.

Another method is to cut the blank out from the individual coated and impregnated sheets of fabric and then axially stagger these round sheets when stacking them to obtain the proper face thickness. This staggering of the warp and woof lines of the fabric utilizes its bias strength and permits the application of a higher horsepower rating per inch of face than is possible with gears cut from boards, according to the manufacturer. This stacking of the die-cut sheets is done before the heat and pressure are applied to transform the Bakelite. These die-formed blanks, it is said, are particularly adapted to the requirements of manufacturers who machine their gears in quantity as the size of the blanks is such so as to eliminate the waste incurred when cutting the blanks from boards.

There is still another method of making a fabric-base, non-metallic gear material which does not use the Bakelite resinoid process. This gear is made of an impregnated cotton fiber. Originally this gear was made of layers of cloth, assembled between steel end plates, compressed and fastened together with studs. The teeth were then cut. The result was a cloth gear which was, in general appearance and method of assembly, very similar to a rawhide gear.

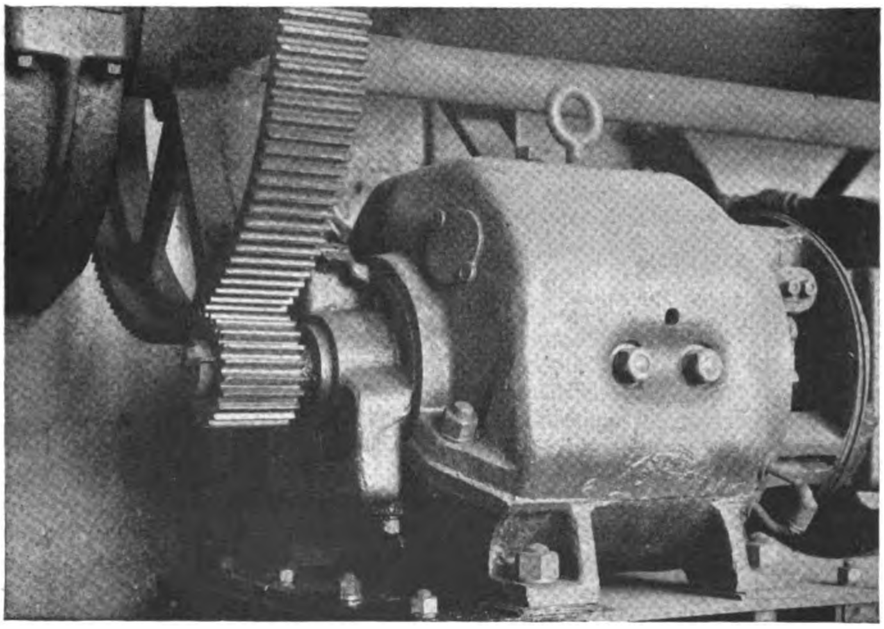
At present, instead of using cloth, cotton fiber in the form of a batting is compressed into thin sheets and disks are die-cut from these sheets



Here a non-metallic gear is used as an idler between the metallic motor pinion and the gear in the head of the lathe.

to the required diameter. A number of these disks, depending upon the desired gear face, are assembled in steel tubes, between steel endplates and compressed at about 8 tons per sq.in. While under compression holes are drilled and tapped and studs are screwed through the entire structure of endplates and fabric, thus holding the gear blank in permanent compression. These blanks are then put through a certain process in which they are subjected to heat and high vacuum, so that air and moisture are removed. This is followed by an oil impregnation which renders the cotton fiber impervious to water and oil and unaffected by heat or cold.

The manufacturers of these materials state that their power transmission ratings should be from 75 per cent of the rating of a corresponding cut cast-iron pinion or gear of the same pitch and face to a ratio of 1 to 1 or better. The American Association of Gear Manufacturers recently adopted the recommendation that all non-metallic gears be estimated on a basis of three-quarters the rating of a corresponding cast-iron gear.



In this drive a non-metallic pinion is mounted on a 5-hp. crane bridge motor.

The permissible rating of a gear should be influenced by the service conditions in the same way as any other item of mechanical power transmission equipment. For example, the maximum load should be considered always and in case of a motor drive an allowance made for at least 50 per cent overload. Where the duty involves the starting of heavy loads or frequent reversals under load, an allowance of 100 per cent overload should be made.

In estimating the capacity of a non-metallic gear, it is difficult to make a direct comparison between the strength of the non-metallic and the metallic materials. For example, the accepted standard fiber stress value for these non-metallic materials is 6,000 lb. per sq.in. (with higher rating for specially-prepared products) as compared to 8,000 lb. per sq.in. for cast iron, 12,000-15,000 lb. for cast steel, and 15,000 up to 35,000 lb. or more for steel, depending upon the composition and heat-treatment.

The manufacturers of non-metallic gear materials do not consider it reasonable to compare the rating of their products according to these stress values. This is for two reasons. First, the treated, alloy-steel pinion driving the cast-iron gear is considerably stronger than its mate, and so a gear to replace it would not need the same high strength. The treated steel gear is used because of its wearing qualities, rather than its strength. Also, the non-metallic materials have a resiliency that does not exist in metals and this factor aids the non-metallic material to meet an impact load without the probability of fracture that might be present in a more brittle, or rather in a less resilient, material. It is stated that the safe working load of the non-metallic material does not decrease with increased speed of the gears nearly as rapidly as does the safe working load value of the metal gear-tooth. Much experimental work is being carried on at present to

(Please turn to page 574)

Controlling Power Input to Wood Pulp Grinders

by special electrical regulating devices that are applied to the continuous feed of synchronous-motor-driven magazine grinders

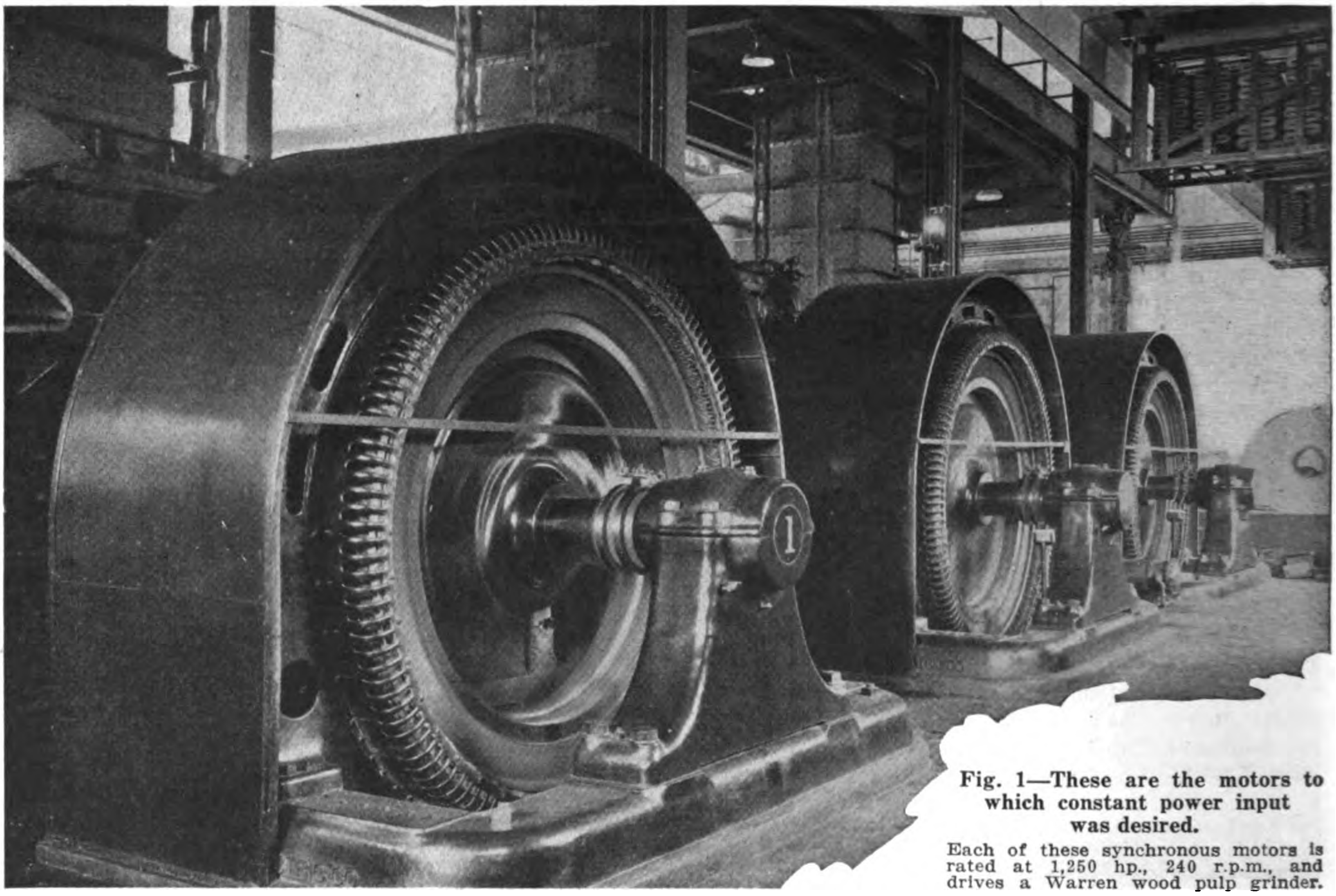


Fig. 1—These are the motors to which constant power input was desired.
Each of these synchronous motors is rated at 1,250 hp., 240 r.p.m., and drives a Warren wood pulp grinder.

By F. A. BYLES
Flow Meter and Regulator Engineering Dept., General Electric Co., Schenectady, N. Y.

THE tremendous increase in the demand for high-grade wood pulp in the paper industry of this country brought about the development of a wood pulp grinder of large capacity. The continuous-feed, magazine grinder of the Warren type was developed to fill this need, and with its development came the problem of load regulation. This type of grinder is usually driven by a synchronous motor and, in order to obtain a long-fiber, high-grade pulp it is necessary to keep the power input to the grinder at a steady value.

The installation recently made by the Iroquois Pulp and Paper Company, Thompson, N. Y., is a good example of modern methods of grinder regulation. This installation is of the single-grinder type (one stone driven by one motor), the regulating and control system being considerably less complicated than that used when two grinders are driven by one motor, although the general scheme of regulation for this latter method is the same except that additional control apparatus is necessary to allow one or the other of the wood-feed motors to be stopped and the load automatically reduced to one-half.

In Fig. 1 are shown three synchronous motors, each of which is coupled to a Warren magazine grinder. Each motor is rated at 1,250 hp., 240 r.p.m., 2,200 volts.

The grinders themselves are shown in Fig. 5. From the floor above the wood is placed in the vertical magazine and is fed down against the grinder stone by four toothed chains which are operated by the series motor *A* shown in Fig. 6.

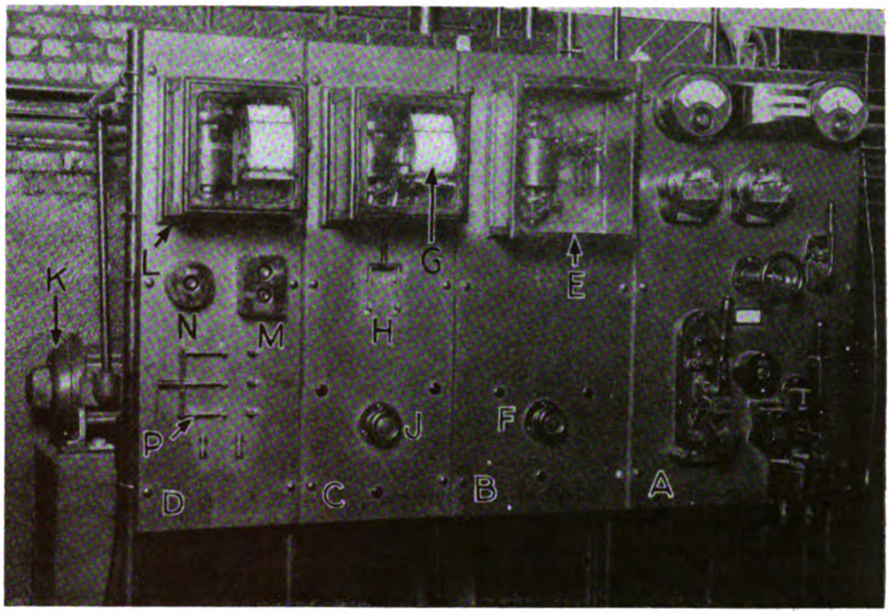


Fig. 2—These panels control the motor shown at (A) in Fig. 6 so as to insure a constant load on the synchronous motor (shown in Fig. 1) driving the grinder.

This motor is connected to the chains by means of a series of worm gear reductions, so that the actual chain feed is only a few inches per minute.

The speed of the grinder feed motor determines the power taken by the main synchronous motor and, by adopting a suitable regulator, the power input is kept at a steady value.

One of the combined control and regulator panels is shown in Fig. 2. The right-hand panel *A* provides for starting, stopping and controlling one of the 1,250-hp. synchronous motors. Panel *B* supports the load regulator *E* and its rheostat *F*. The curve-drawing wattmeter *G* on panel *C* records the regulated load. Switch *H* provides a means for disconnecting the control circuit which, in this instance, is 125 volts, and is supplied by the exciter which furnishes excitation for the three synchronous motors.

The rheostat at *J* provides a means for hand control when desired and is connected in series with the shunt field circuit of the d.c. generator which furnishes power for the grinder feed motor. The induction motor *K*, which drives this generator is shown behind the switchboard, mounted on a substantial concrete base. The curve-drawing ammeter *L* mounted at the upper end of panel *D* charts the current input to the grinder feed motor. An inspection of the current curve with respect to the power input curve enables the operator to determine the grinder performance to a very close degree. Push-button station *M* provides a means for starting and stopping the motor-generator *K*. Push button *N* is connected in the undervoltage release circuit of the main circuit breaker in the synchronous motor feed line, and provides a means for instantly disconnecting this motor from the line when so desired. Switch *P* provides a means for reversing the grinder feed motor when it becomes necessary to back up the wood in case of uneven grinding, or to remove the pressure from the stone.

When in operation a continuous supply of logs varying from 4 to 10 in. in diameter is fed down against the grinder stone. Streams of water playing on the stone prevent excessive heating and carry away the ground pulp-wood to the storage tank.

The general scheme of connections for the regulator is shown in Fig. 4. The switching and hand control apparatus has been omitted from this diagram for the sake of simplicity.

With reference to this diagram, the basic principle of operation is that of automatically controlling the shunt field of the d.c. generator which furnishes power for operating the grinder feed motor, so that constant power input to the main grinder motor will be obtained.

The main control element of the regulator is of the wattmeter type. The potential coils P_1, and P_2, which are connected to two potential transformers, are mounted on the pivoted center shaft and are arranged within, and at right angles to, the current coils C_1 and C_2. The current coils are connected to two current transformers in the line feeding the synchronous motor driving the grinder that is to be controlled. The torque produced by these coils is balanced against a pair of spiral springs. Load adjustment is obtained by spring S_1. The main control contacts (actuated by an arm connected to the shaft) are connected so as to open and close a circuit across the windings of relay *R*, which are connected to the 125-volt exciter busbars through resistance R_4. This relay causes a rocker arm to move over a series of contacts which in turn are connected to sections of resistance in series with the shunt field of the d.c. generator. When this rocker arm is in

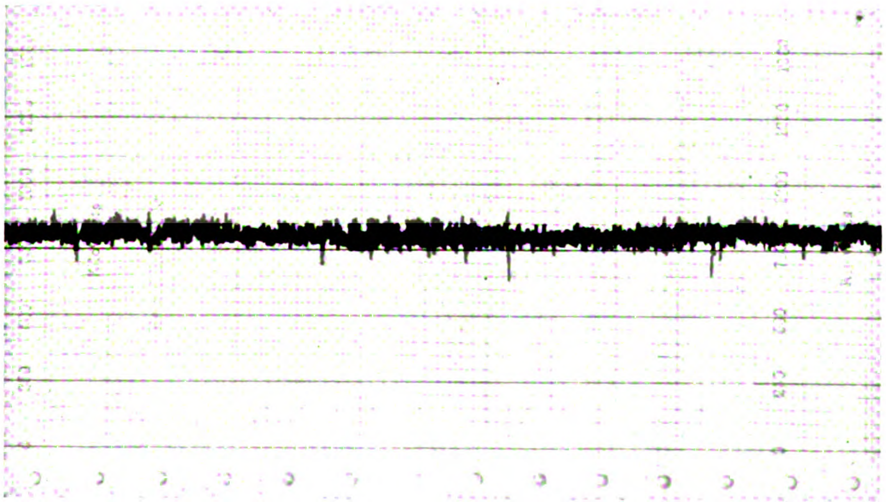


Fig. 3—This graphic meter record is from the recording wattmeter measuring power input to one synchronous motor.

The close regulation of the power input to the motor may readily be seen.

the extreme forward position *1* the resistance is entirely cut out and the highest generator voltage is obtained; when it is in the extreme backward position *2* the resistance is entirely cut in, which gives the minimum voltage.

Armature *A* of relay *R* shown in Fig. 4 is connected to the plunger of the dashpot by means of springs S_3 and S_4 in such manner that it floats between them. This allows the armature to travel a very short distance without moving the dashpot plunger (which moves in heavy oil), thereby obtaining very rapid contact action between the rocker contact and two or three of the stationary contact bars. When it becomes necessary for the rocker arm to take up a new position, a sustained pull or release on armature *A* causes the spring S_3 to come into action and allows the dashpot plunger to rise or fall giving the rocker an entirely new field of action.

The cycle of operation is as follows: The torque of the main control element increases as the load comes on until a balance is obtained between it and the spring mechanism. At this point the contacts operate the relay magnet, which in turn cuts in resistance in the generator field circuit, causing a lower generator voltage and a slower speed of the grinder feed motors. The lower speed of the feed motor causes the grinder motor load to be reduced slightly. This load reduction at once reverses the regulator operation by causing the relay rocker arm to rock in the opposite direction, cutting out a little generator field resistance, thus raising its voltage and the speed of the feed motors. This action causes the grinder motor load to rise slightly and the cycle is repeated. When in actual operation the contact action is rapid. The relay rocker arm takes up its position by rolling forward or backward as determined by the main control contacts until its regulating position is established, when it vibrates between two or three contact bars until the load requirements again cause it to take a new position of vibration.

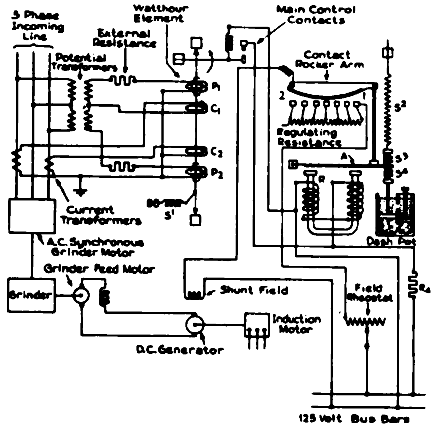


Fig. 4—Connection scheme of the control shown in Fig. 2.

The load curve illustrated in Fig. 3 shows the regulated load of one of these grinder motors when in actual service.

Unusual Cause of Transformer Failure

A CUSTOMER recently returned to the manufacturer some samples of oil taken from a transformer which had failed. The oil had been found dirty, and seemed to carry a large amount of black sediment for which the customer could not account.

Analysis of the oil showed small quantities of aluminum, for which the laboratory could give no explanation. The findings were reported to the customer, with a request for a possible explanation of the aluminum.

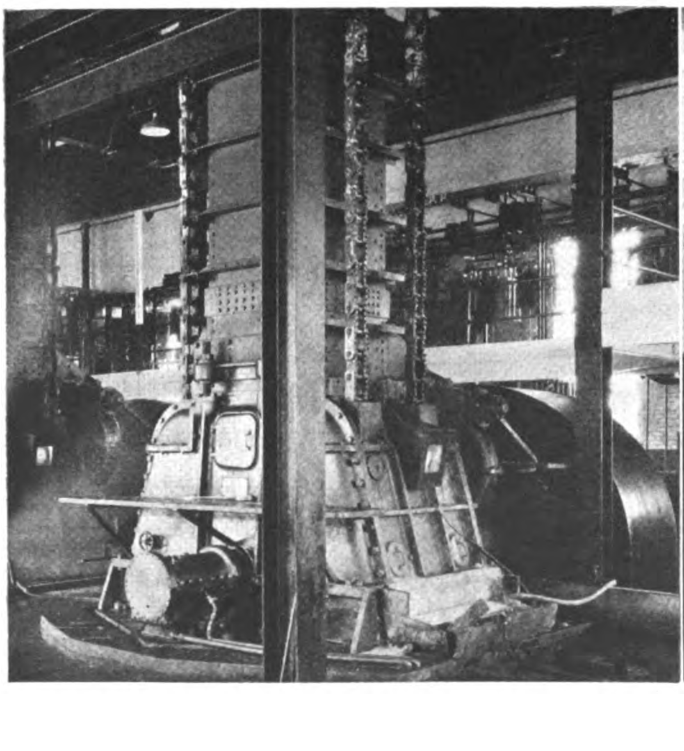
The matter was cleared up in a letter which read:

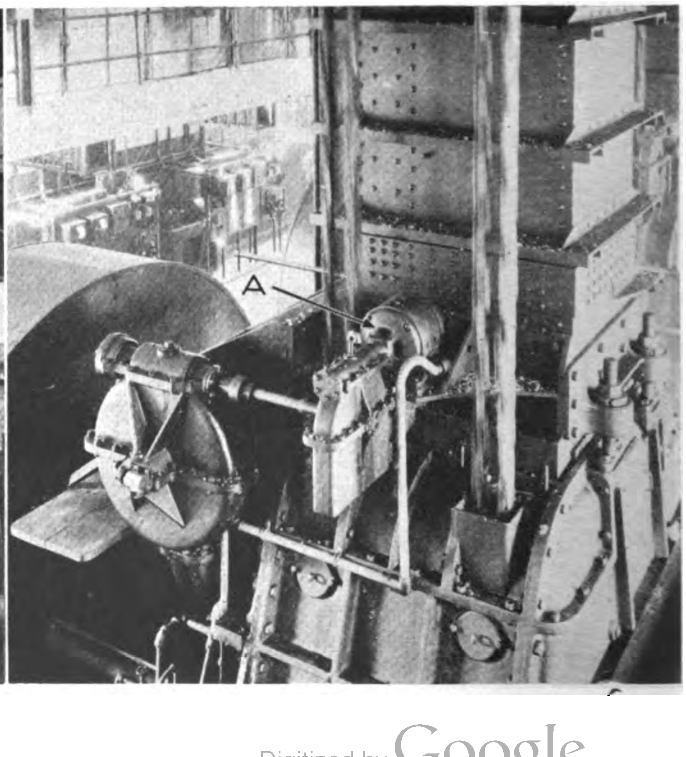
"The surprising results, which you have found, showing aluminum in the oil, are undoubtedly due to the fact that we painted the transformer tanks in the building with aluminum paint, using a paint spray. This no doubt saturated the atmosphere in the building with aluminum powder which was taken into the transformers through the breathers.

"This analysis has, therefore, given us a very valuable suggestion, and in the future we will see to it that the breathers are closed when aluminum paint, or any paint with a spray is used."

Figs. 5 and 6—Wood pulp grinders at plant of Iroquois Pulp and Paper Co. to which automatic load regulation was applied.

At the left is shown one of the three Warren pulp grinders with its driving motor to the right. The four vertical chains feed the wood against the grinder stone. These chains are driven by motor *A* in the close-up view of the grinder shown in the illustration at the right.





Selecting Commutator Mica

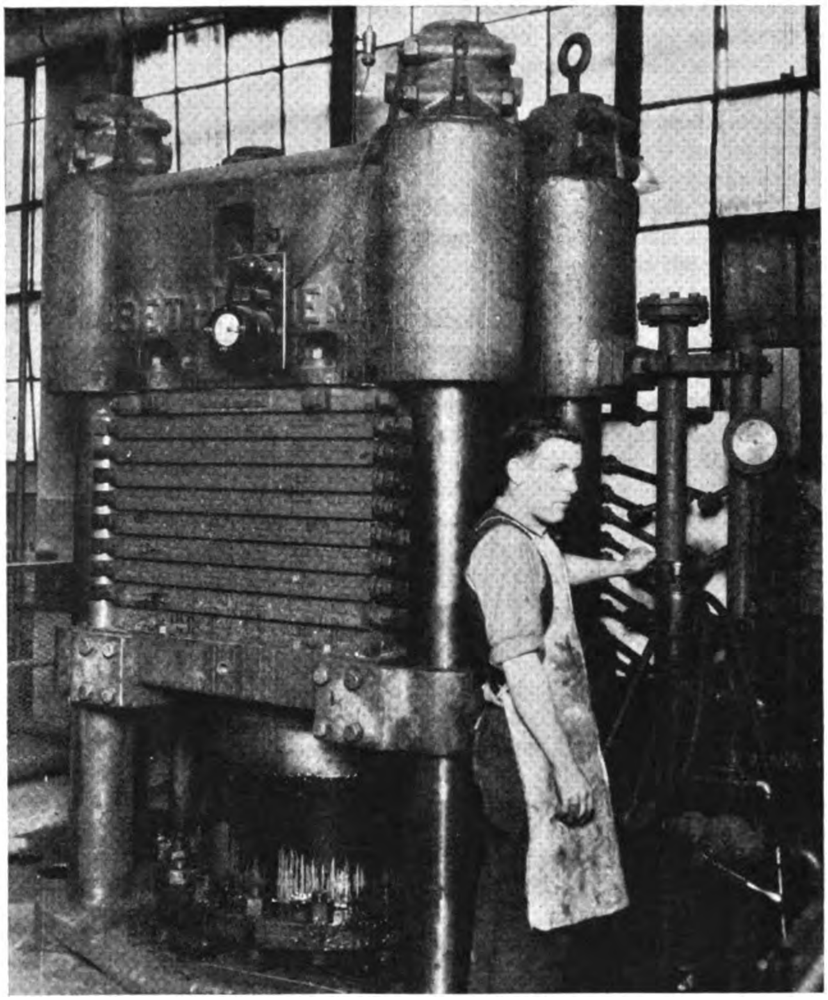
for Direct Current Motors

THIS, the first of a series of articles on commutators, takes up the selection, use and installation of mica as used in commutators of industrial motors. The second article of the series will discuss the subject of commutator bars while the third will tell how to assemble them. These articles will appear in early issues.

By JESSE M. ZIMMERMAN
Renewal Parts Engineer,
Westinghouse Electric & Mfg. Company
Pittsburgh, Pa.

IN BRIEF, a commutator is a mechanical means for converting the alternating current in the rotating armature of a generator to a continuous current which is to be supplied to an external circuit. In the case of a motor, the commutator takes the continuous current from the external circuit and delivers it to the armature coils, in such a manner that it will flow in alternate directions as the coils are forced alternately through fields of different polarity. These functions are accomplished by having the armature coils connected to copper segments, which are separately insulated and mechanically sustained, so that they alternately come in contact with a set of positive and negative brushes which are connected to the external circuit.

To the average user the theoretical principles of commutation mean but little. He is interested mainly in how the commutator is mechanically designed, why it was so designed and how can it best be maintained. Therefore, the writer will dwell in this series of articles upon the history and evolution of the commutator, the difficulties experienced along the path of progress, the present-day practice in manufacture of commutators and maintenance and repair of commutators, so as to assist in better understanding of proper commutator maintenance and to serve as a guide for purchasing renewals for repairing the same.



Steam-heated hydraulic press used for pressing commutator mica plate. Great care is taken during the pressing operation to insure uniform density. Special pads are placed between plates in the press to obtain this result.

In the early days of motor manufacture some difficulty was experienced with the operation of large-sized commutators when the motors were placed on test and later in service, due to high bars appearing in them. It was necessary to dismantle the motor, tighten the commutator and re-surface the brush face before the motor could be put in service. Sometimes this operation had to be done several times. The unfortunate part of the situation was that this so-called seasoning operation had to be continued after the motor had been in service a few months. At the slightest indication of high bars the motor had to be dismantled. This led to a wide research to investigate different insulating materials as well as ways and means of providing a better mechanical structure.

In the early commutators, the mica strips were made of mica plate having a high bond content. Although the plate was made of high-grade mica splittings the methods of making mica plate were less advanced. The commutators were made arch-bound and while the commutator was going through the seasoning period, the bond would ooze out from between the bars. This caused the mica to shrink, relieving the arch-binding between the bars because the seasoning process did not completely harden the bond. In fact the bond continued to ooze out when the motor went into operation. Due to centrifugal force the bars rose where the bond oozed out excessively, thereby causing high bars. It is evident then that one of the difficulties was due to the

mica strips used in the construction of these commutators.

A search was then made for an insulating strip which would be more adapted to commutator service. Asbestos and fishpaper were two of the numerous insulating materials tried. It was found, however, that a mica plate with a low bond content and properly seasoned was superior to all other materials tried.

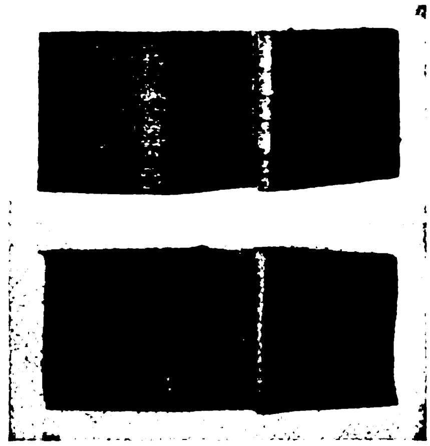
There are two different types of mica splittings used in present day industrial commutators, namely white and amber mica splittings.

White mica splittings known as hard mica come from mines in India and are capable of standing a very high temperature before decomposing. Use of this material, however, is limited to commutators which are undercut. If the commutators were not undercut, the mica, which does not wear as rapidly as the copper, would permit the brushes to ride on the mica thus causing a very rapid burning action between the brush and the commutator surface that is very injurious.

Amber mica splittings which are soft and more easily compressed than white mica are mined in Canada and East Africa. This soft quality makes them more adaptable for commutator use because the mica segments will wear away as rapidly as the copper thus eliminating the necessity of undercutting. This is an advantage for there are some applications of direct-current motors where undercut commutators are undesirable. This is particularly true in textile mills where the lint collects between bars of an undercut commutator and carbonizes thereby causing a short. Wood pulp and paper mills provide similar examples. For such applications as these the amber mica is desirable despite the extra cost.

It is well to carefully ascertain whether renewal commutators have segments containing amber or white mica. Very often the difference in price which may exist between two bidders, can be explained by the fact that one will furnish amber mica while the other will furnish white mica.

The process of making mica plate from the two different kinds of splittings is the same. It is necessary that the splittings be free from clay spots, metallic spots, cross grain, heavy edges and heavy pieces. The splittings are usually about one mil thick and are held together by a minimum amount of dry bond

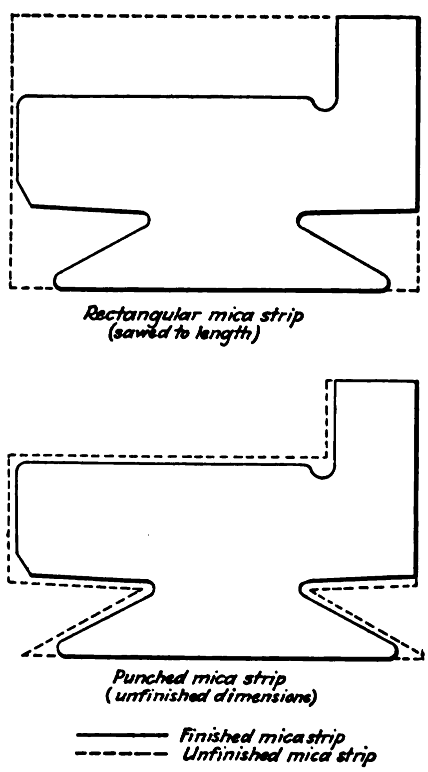


Results of tests made on commutator mica to determine whether the bond was properly seasoned.

These two illustrations show two sets of mica strips after having been heated and pressed under identical conditions. The top illustration shows strips in which the bond was properly seasoned and the slippage of mica and oozing of bond negligible. In the bottom illustration there are visible signs of slippage of mica and oozing of bond indicating that the bond was not properly seasoned.

which will flow at a medium temperature.

Use of the "dry method" of making mica plate permits the use of a bond which does not contain alcohol as a solvent. Alcohol as a solvent is dangerous because it does not completely evaporate. When mica plate containing alcohol is used in a commutator, the alcohol may evaporate and migrate to some part of the commutator and condense. This sometimes occurs at the point of the V's producing a weak spot in this location. Great care is taken during the pressing operation to insure uniform density as shown in the illustration at bottom of page 560. Special pads are placed between plates in the press to obtain this result as is shown in the illustration of the steam heated hydraulic press on page 557.



Rectangular pieces of mica are more economical for small lots of segments.

To insure as little waste as possible the bars should be placed on the mica strips as shown. They may be shellacked to the strip, after which the segments are cut apart and trimmed to size.

The mica plate must pass through a seasoning operation which serves to make the bond infusible. After the seasoning operation, the mica plate is milled with an allowable variation of plus or minus 0.001 in. If the variation exceeds this value, the distance from any bar to the corresponding bar under the next pole may vary more than plus or minus $\frac{1}{32}$ in. Some manufacturers of mica plate only pass the plate through a sanding machine and do not machine it, thereby resulting in a plate thickness that is not within the allowable variation. One can distinguish this type of plate by the marks of sand rolls.

Mica plate will compress a certain amount when the assembled segments are heated and drawn tight with the clamping ring. This compression factor must be taken into consideration when milling the mica plate.

Every sheet of finished mica plate should have a surface coat of pure orange shellac. This treatment has the following advantages: (1) It prevents flaking and scaling of the mica splittings in handling and storage. (2) It keeps the mica plate free from dirt and moisture while in storage. (3) It tends to reduce oil and moisture absorption when the commutator is in service. The shellac cements the adjacent bars to the mica strip, thus reducing the creepage of oil and moisture along the copper bar. (4) It facilitates assembling. By heating segments before the V's are machined, the shellac glues the segments together. Therefore, when the banding wire is cut, they remain in a firm body and will not fall apart. This makes it possible to assemble the parts of a V-bound commutator without skewing the bars.

Mica plate should not absorb more than three-fourths of one per cent of its own weight of oil when placed

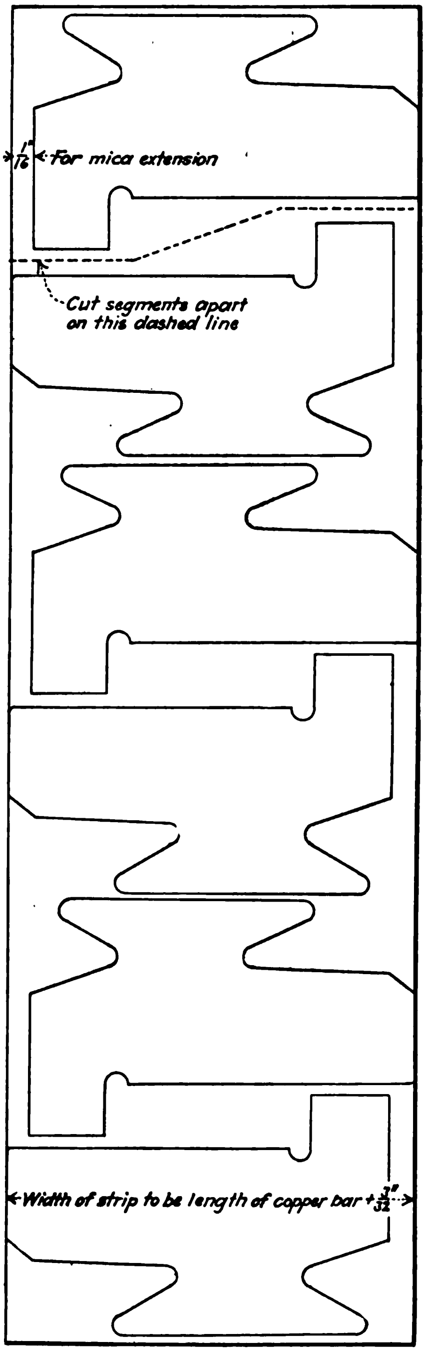
between two commutator bars under working pressure and immersed in oil for 24 hr. The oil absorption quality of mica is dependent upon the amount and quality of bond. Unless the entire surface of every splitting is covered with bond, oil getting on the commutator will find its way into the mica plate lodging between these splittings. Therefore, it is just as essential that the finished mica plate have a sufficient amount of bond to prevent oil absorption as it is for it not to have an excess amount of bond which will ooze out when the commutator is in service.

Mica plate should be able to stand a pressure of 10,000 lb. per sq.in. when heated to 150 deg. C. without showing slippage of mica or oozing of bond. Slippage of mica and oozing of bond are due to excess of bond which has not been properly seasoned. It is very important, then, that all commutators and more especially the arch-bound commutator should be made of a mica plate which has the bond properly seasoned.

A good means for testing mica strips, to determine whether the bond has been properly seasoned, is to place a dozen strips between two parallel steel bars which have a bolt at each end to exert a clamping action. The steel bars should be strong enough so that they will not bend. After the strips have been placed between the bars, tighten the nuts with a "trip wrench" and measure their thickness. Place them where they can be heated to at least 150 deg. C. but do not allow a flame to strike the strips as it will consume the bond. When they are thoroughly heated again tighten the nuts with the same "trip wrench" and allow to cool. Once more measure the thickness of the assembled strips to determine the amount of compression. Absence of slippage of mica or oozing of bond is an indication that the bond was properly seasoned. If the bond squeezed out, the strips should not be used in a commutator.

Photographs were taken to show two groups of mica strips after they had been under identical tests as described in the foregoing. The illustration at the top of page 558 shows no effect due to compression because the bond was properly seasoned. The bottom illustration, however, shows the slippage of mica and the oozing of the bond. This clearly illustrates how the two types of mica plate will act after they have been in the commutator. It would be well for operators to give the above outlined test to a sample of the mica plate which is to be used for repairing commutators.

The question of how to order mica strips for repairing commutators has been asked by many maintenance men. The manufacturer of the original commutator will supply mica strips in one of two ways: namely, (1) Punched to an unfinished size, and (2) rectangular mica strips.



Mica strips punched to an unfinished size are more economical if many strips of a given size are required.

The copper bar is shellacked to the strip as shown and the strip trimmed to size and V's cut by means of a knife and knife file.

When the V's and necks of the copper bars are punched for manufacturing purposes, the mica will be punched in the same manner. This mica die will leave 1/16 in. of material on each side of the V for finishing purposes. This is shown in the illustration at the bottom of page 558.

When the mica strips are received in this form, they can be finished very easily by pasting the strip to the copper bar with shellac. When the shellac is dry, place the two in a vise with the mica strip toward you and cut the V's to the same size as the copper V's. Be sure that the stroke of the knife is toward the copper. In this manner the mica will cut without tearing. It may be necessary to take a finishing cut with a knife file. Handle the file in the same manner as the knife.

When there are only a few commutators of a given size, it does not pay to make a die for punching the V's and necks in the rough, for it is cheaper to make the commutator from the rectangular copper bars and mica strips than to make a set of punching dies. Where this condition exists, the mica strips will be rectangular for repair purposes.

When rectangular mica strips are received, it is best to paste them to the bar with which they will be used. Cut the V in the same manner as mentioned in the forgoing.

When a complete commutator is to be refilled a set of mica strips will be required. Some repair men do not care to use the mica in either of the above mentioned forms because it requires too large a stock to take care of such a varied line of motors as is usually found in the average industrial plant. Under these conditions it will only be necessary to carry the mica plate in sheet form for the three standard thicknesses.

By careful consideration the amount of scrap can be kept to a minimum by the following method:

Assume that the copper bars (finished) are 5 7/8 in. x 3 in. If the sheet is 24 in. x 36 in., it can be cut into six pieces 6 in. wide and 24 in. long.

Apply a coat of pure heavy orange shellac sparingly on the one side of each piece. Lay the copper bars on the shellacked side in the manner shown in the drawing on this page. It will be possible to get eight mica strips out of each piece.

If a rear mica extension is desired, lay the bars on the plate so that there will be 1/16 in. of mica extending from the rear of the bar. This mica

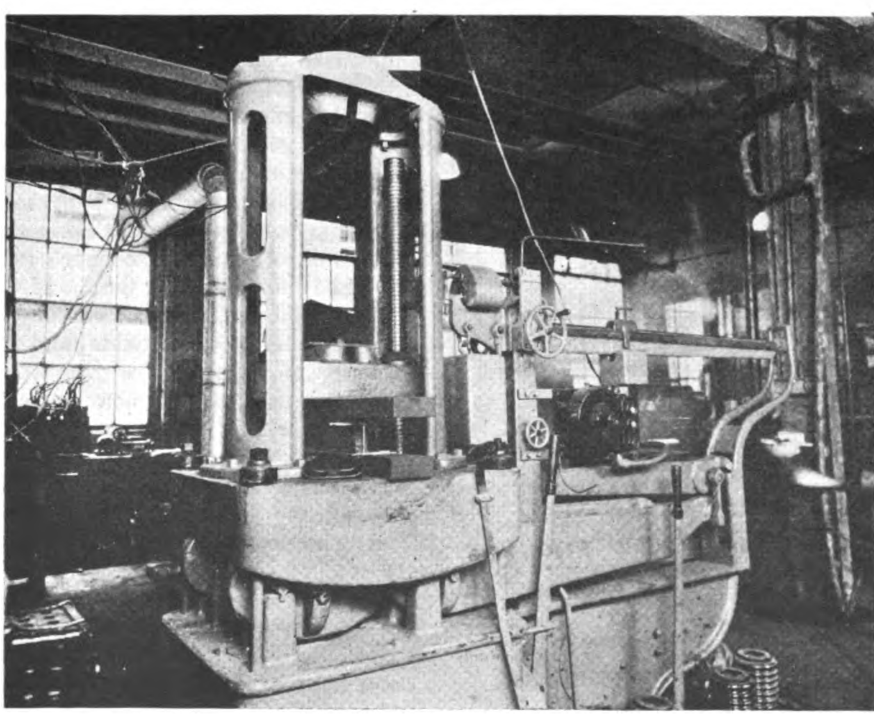
which extends in the front can be removed by the machine tool after the commutator has been assembled or with a knife when the V's are finished.

After the shellac dries, saw the strips apart (as shown by the dashed line) with a band saw if one is available. If a band saw is not available they can be cut apart with a coping saw. If a coping saw is used a piece of fuller board should be placed in the vise so that the edge is even with the place where the mica plate is to be cut. Care should be taken so that the stroke of the saw will be toward this piece of fullerboard in order to prevent flaking of the mica. If a band saw is used, the set of the saw should be small and the throat in the table for the saw to pass through should be very narrow.

After the strips have been cut apart, the V's can be sawed out with the band saw or cut out with a knife. It may be necessary to take a finishing cut with a knife file before assembling.

After the V's have been finished, do not remove the mica strips from the copper bars but assemble them while they are stuck together. After the commutator has been assembled cold, align the bars properly. Heat the commutator to a temperature of 125 deg. to 150 deg. C. and tighten while under pressure. The assembly of commutators will be treated in detail in the third article of this series. The second article, which will appear in an early issue, will discuss the selection of copper as used in making commutator segments.

Special testing machine used for measuring the density of commutator mica strips.



Lamp Protection Necessary in Atmosphere of Explosive Dust

In an article on safe lighting equipment for dusty locations, published in *Chemical and Metallurgical Engineering*, Kirk M. Reid, Engineering Dept., National Lamp Works of General Electric Co., stated that extensive tests have been made by the National Lamp Works, to determine what hazard is involved in the use of incandescent lamps in atmospheres containing explosive or inflammable dust.

Tests made by the Government have shown that nearly all finely-divided dust, if combined with the right proportion of air, will explode or ignite when brought in contact with an open flame. It has also been demonstrated that such dusts may be exploded by static electricity, by the electric arc from a short-circuit or a loose connection in a lamp socket, or by contact with the white-hot filament of either a vacuum or a gas-filled lamp. The National Lamp Works tests have proved that the hazard due to bulb breakage is not confined to the gas-filled lamps. Any vacuum lamp, except possibly extremely low-wattage lamps, such as the 10-watt and the 15-watt, will ignite an explosive dust cloud if the glass bulb is cracked or shattered.

A number of tests have also been made to determine the smoking and ignition temperatures of various dusts which are commonly found. These temperatures, when compared with the temperatures of different sizes of modern vacuum and gas-filled lamps, indicate that there is a reasonable margin of safety, in most cases 150 deg. or more. No trouble was experienced in making the dusts smoke and char, but they could not be made to ignite even when packed tightly around the lamp bulb. However, when dust accumulates on a lamp bulb and is successively heated and cooled as the lamp is turned on and off during a long period of time, the dust changes to a hard crust whose temperature may be raised to the danger point.

In considering what protective measures are necessary for incandescent lamps in atmospheres of explosive dust, it does not make much difference whether the hazard arises from the accumulation of dust on the bare lamp bulb, as is commonly supposed, or whether the real danger lies in breakage of the bulb, as the tests indicate. In either case the answer is that all incandescent lamps, vacuum and gas-filled, except those of the lowest wattages, should be protected. Under ordinary conditions, with free circulation of air around the lamp bulb, it is not likely that a fire will be started readily by vacuum lamps of small or medium size, but it is well to be on the safe side and equip them with heavy wire guards, at least. The larger vacuum lamps, such as the 100-watt, have heavier filaments which retain their heat for a relatively long time and thereby constitute a hazard in case of bulb breakage. Hence, in view of present knowledge on the subject, it is clearly unsafe to use bare, unprotected vacuum lamps of the larger sizes, in atmospheres containing explosive dusts. It is not sufficient to equip these large vacuum lamps with wire guards only; unless they are enclosed in dust-tight or vaporproof lighting units they are definitely dangerous.

Where the lighting units employed are subject to breakage by being struck it is well to take the additional precaution of supplying heavy wire guards. Also, under extremely hazardous conditions, such as arise from the presence of highly-explosive vapor in the air, it is safer to supply the artificial lighting from sources entirely outside of the room.

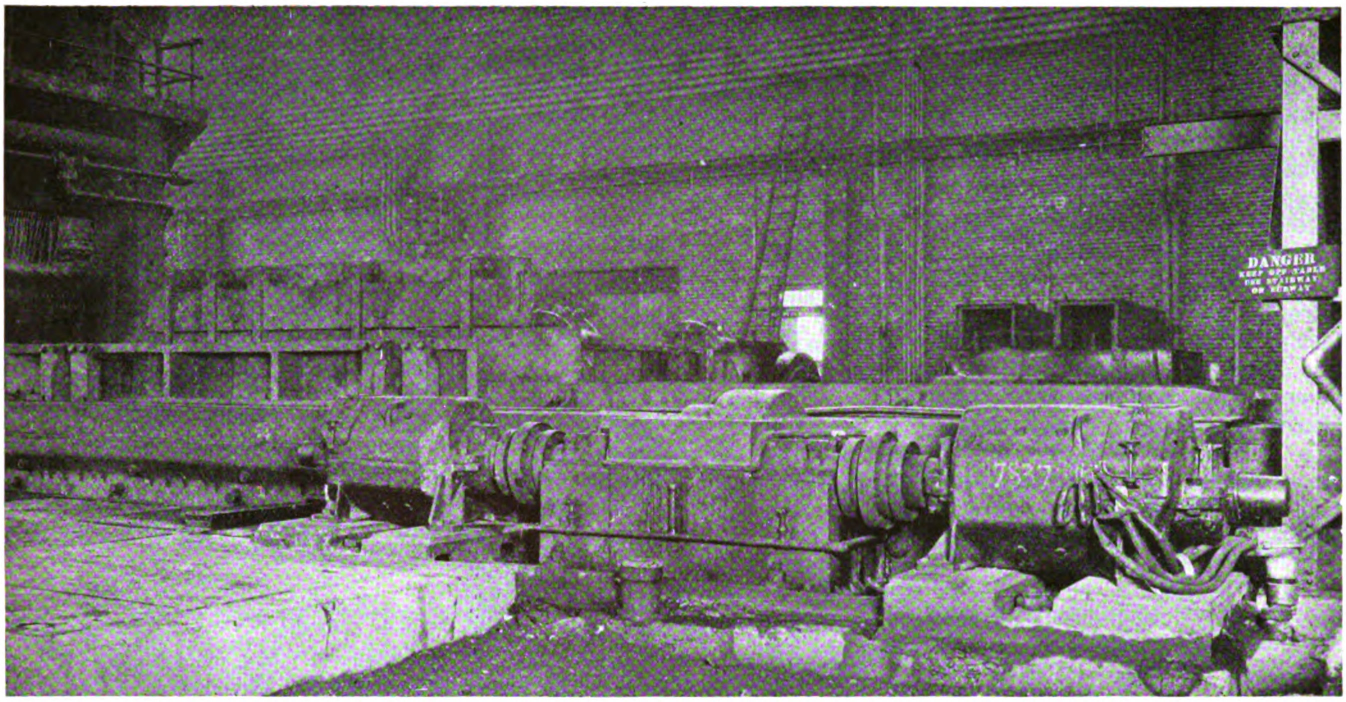


Fig. 1—Flexible couplings are widely used on steel mill auxiliary drives. Laminated disk couplings are used to connect the motors to the drive. These two mill-type motors drive a geared line-shaft which in turn drives the individual rollers on the front table of a blooming mill.

Using Flexible Couplings on Motor Drives

By GORDON FOX
Electrical Engineer
Freyn Engineering Company,
Chicago, Ill.

AFTER having decided upon the type of motor and control for a given drive application, only half of the job has been performed. It is also necessary to select the mechanical element that will transfer rotary motion from the motor shaft to the driven machine. There are six common methods in general use for connecting the motor to the driven machine. These are: (1) By direct connection using solid or flexible couplings, or clutches. (2) By means of belts, ropes and accompanying pulleys and lineshafts, or short-coupled drives using modified belt or rope arrangements. (3) Through the use of roller, silent chain, or other forms of chains. (4) By means of gears or gear chains. (5) By the use of speed transformers or what are commonly known as speed reducers; and (6) by means of a special form of speed reducer known as the variable speed transmission.

These different mechanical elements will be discussed in a series of articles of which this is the first. This article will treat couplings and magnetic clutches, which are in reality a form of coupling.

Many motors are direct connected to the driven machine. Solid or rigid flange couplings would make an ideal connection were it not for the fact that they are too rigid and make no allowance for slight errors in misalignment or for the errors that come with wear of bearings, settling of frames or foundations, and other operating difficulties. With any misalignment and a rigidly connected shaft, experience shows that some of the troubles to be expected are: excessive shaft binding, loss of power through friction, excessive wear of bearings, difficulty of lubrication, and sometimes even broken shafts or couplings.

Perfect alignment, if it were possible to be attained and kept would be ideal. Builders of high-speed, direct-connected machinery such as turbines, line up shafts to within 0.003 or 0.004 in. On slower-speed machines, a greater allowance is usual and permissible. Hardly ever, however, on ordinary equipment does the misalignment exceed $\frac{1}{16}$ in. The result is that flexible couplings are required.

One of the most common complaints on flexible couplings arises from a mistaken belief that they will take care of any misalignment and do not need any attention after once being installed. In other words they are thought of as universal joints rather than flexible couplings. Flexible couplings do take care of a certain amount of misalignment, but operate much more satisfactorily both as to the coupling and as to the

machines, if maintained as nearly in perfect alignment as possible. It is not the function of a flexible coupling to compensate for careless or incompetent erection, nor for lack of reasonable maintenance attention.

One manufacturer of a very well known flexible coupling states, "We want to urge operators of direct-connected machinery that they line up their shafts initially just as carefully as they would do if they were attempting to use rigid couplings. This should be done whether or not the connected machines are received from the manufacturer and mounted upon a common bedplate, for bedplates will at times spring a sufficient amount to cause operating trouble. Therefore, the shafts

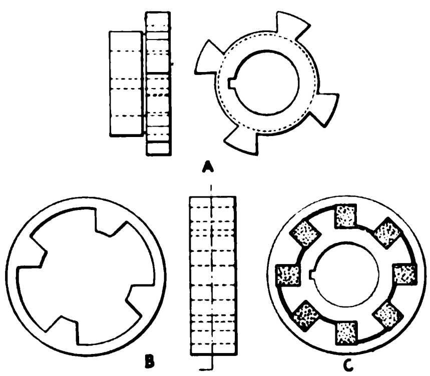


Fig. 2—This coupling uses standard hydraulic packing for the resilient material.

should be lined up after the bedplate is grouted into position. Also, the alignment of all direct connected machines should be checked at least once or twice a year. By checking the alignment it is not necessarily meant that the alignment will have to be corrected two or three times a year, but that in the case of many couplings where it is so easy to check the alignment by placing a steel straight edge across the wide flanges at the top, bottom, and sides, that the operator should spend a few minutes to do this rather than to run indefinitely and at some later date find that one bearing has worn to such an extent that the shafts are badly out of line. In such case he might have saved unnecessary wear in the coupling if he had checked the alignment at regular intervals, and corrected the alignment when he found the shafts were getting badly out of line."

Couplings of both solid and flexible types are in use for motor applications. Solid couplings may

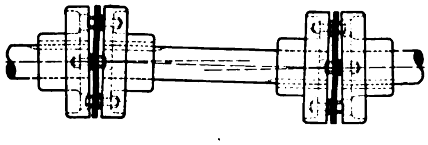


Fig. 3—This arrangement is used where a large amount of parallel misalignment must be compensated for.

Two, single type, flexible couplings are connected together by an extension shaft. The manufacturer of this coupling states that a maximum of 3/64 in. of parallel misalignment may be taken care of for each foot of extension shaft.

be used for motor-generator sets and for similiar applications where definite alignment of three or more bearings can be insured and where there is little likelihood of loss of alignment through bearing wear or movement of parts. Solid couplings are almost always of the safety flanged type.

Flexible couplings afford a considerable measure of protection to the motor. They should be used where accurate alignment cannot be definitely insured, where there is any possibility for relative movement between motor and driven machine, where hurried exchange of motors may be required, as in steel mill service, where there is some vibration or shock in the driven machine, or where an end thrust occurs which might be imposed upon the motor. Some types of flexible couplings may also be used for cushioning torque changes, as for reversing drives.

The flexible coupling is necessarily less simple than the solid flanged coupling. It is subjected to

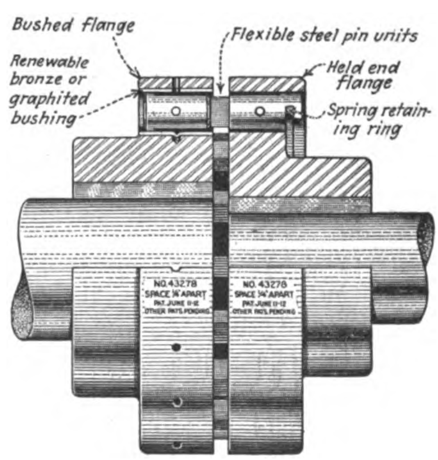


Fig. 4—Pin type of all metal flexible coupling.

Flexible steel pin units are held in bronze or graphite bushings placed in one of the flanges of the coupling as shown. The other end of the pin unit is held fast in the other flange. The steel pin units are free to slide $\frac{1}{8}$ in. within the bushings.

and is expected to operate under faulty conditions. It is only recently that couplings have been developed that will withstand successfully the more severe applications. Although there are many designs of flexible couplings, they may be divided into two main classes, namely those that derive their flexibility through the use of a leather, rubber or fiber element and those that are made entirely of metal.

The leather link and leather laced belt coupling and the rubber buffer coupling are among the older types. The latter is still quite popular. Leather belt types are applicable where the torque is unidirectional. Rubber buffer couplings will not withstand serious misalign-

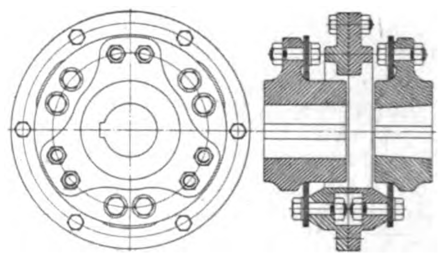


Fig. 5—This is the laminated disc, double-type coupling.

Laminated discs are fastened to each of the two coupling hubs and to a two-part central flange as shown at the left. This coupling can be quickly disconnected by removing the bolts holding the two halves of the central flange.

ment. Both leather and rubber are subject to deterioration and the rubber buffer type requires lubrication to minimize wear on the pins and bushings.

There has recently been introduced a coupling using standard hydraulic packing for the resilient material. This coupling consists of two duplicate flanges as shown at *A* in Fig. 2, one outer sleeve as shown at *B* and eight pieces of packing. The two flanges are keyed to separate shafts; the sleeve goes over the flanges and the packing is placed between the lugs on the flanges and sleeve respectively. The assembled coupling is shown at *C*. Steel springs and phosphor bronze retaining rings at each end of the outer sleeve hold the sleeve and packing in place. In this way the coupling is assembled without the use of any projecting bolts.

The construction of this coupling permits quick disconnection in order to change armatures on motor-driven applications. It is only necessary to remove the retaining

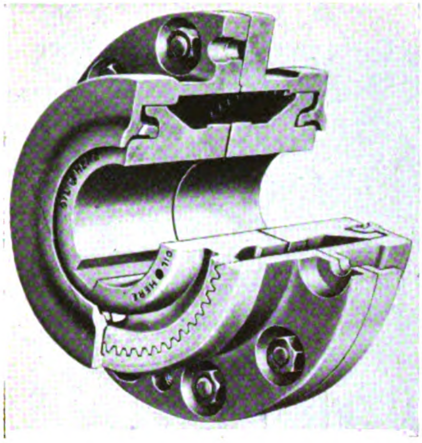


Fig. 6—A flexible coupling using a gear arrangement.
Each shaft hub has an external spur gear meshing with an internal gear on each half of the enclosing case. This then operates with a self-aligning action.

rings, slide back the sleeve and lift out the packing, whereupon the armature with its flange may be lifted out. This coupling compensates for both angular and parallel misalignment of shafts and permits end float. It is said to be adaptable to reversing as well as non-reversing drives.

All-metal couplings have features of desirability. They are particularly adapted for the more severe service applications finding extensive use, for instance, in the steel mill.

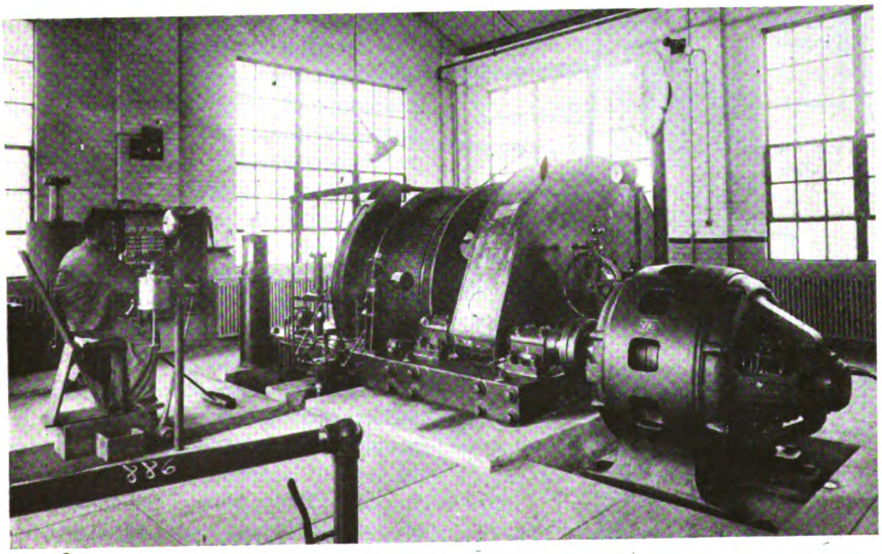
The all-metal couplings may be classified into those types (1) that use pins, (2) those that use laminated discs, (3) those that use springs, and (4) those that use an arrangement of internal and external spur gears.

The pin type of all-metal coupling uses pins that project from each of two flanges into holes in a central disc composed of fiber or leather. The holes in the central disc are slightly larger than the pins which permits the coupling to automatically adjust itself for misalignment.

Another form of pin type coupling uses horizontal laminated steel pins projecting into a central disc made of steel, while a third form uses radial laminated pins which project into slots in a central sleeve placed over them. These types of couplings have been extensively used and are popular. The pin laminations may break after a long period of service, but they do not fail all at once, giving warning if occasionally inspected. Theoretically this type of coupling should relieve end thrust. Practically it is not very effective in this respect as the pins are subjected to stress and they do not readily permit endwise movement unless well lubricated. It is difficult to renew pins in this coupling as they become distorted and take a permanent set so that the pin sockets are out of line. For like reasons, single couplings of this type in which the pins must be removed in separating the coupling, are not adapted to quick changes of motors. Double couplings of this type can be separated without removing the pins. This coupling affords a slight degree of torque cushioning on reversing drives.

A coupling in which the objections mentioned in the foregoing have been removed is shown in Fig. 4. Graphite bushings are used in this coupling so that the coupling is self lubricated. The steel pin units are free to slide ½ in. within the bushings thereby relieving end thrust on the coupling. Flexibility is obtained by means of the flexible steel pin units shown in the illustration. The coupling is quickly disconnected for changing motors by removing the spring retaining ring indicated in Fig. 4.

Fig. 8.—The motor driving this mine hoist is connected to the reduction gear by means of a flexible coupling.



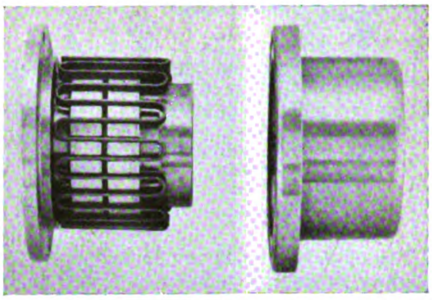


Fig. 7—Well known form of spring type coupling.
The two hubs have tapered slots into which fit tempered steel springs. The slots in the hubs widen inward towards each other so that the spring fits closely in them only at the outer ends and so permits flexibility.

An all metal coupling using laminated discs for the flexible element is shown in Fig. 5. Both single and double couplings of this type absorb end movement excellently. This type of coupling requires no lubrication. It affords little if any torque cushioning effect.

Flexible pin and laminated disc type couplings may be either single or double. The single coupling provides but one flexible element. The double coupling provides two flexible elements and a central floating member. Fig. 5 is a section of a double coupling of the laminated disc type. The single coupling will withstand a little misalignment, perhaps, but very little offset of shafts. The double coupling will operate successfully with greater misalignment and with a slight offset of shafts. Where considerable offset or play in one shaft exists, the condition can be met by separating the two single flexible members and extending the floating member by a spindle, as shown in Fig. 3. The double coupling permits quick exchange of motors or armatures as the floating member is split.

In some types of all-metal flexible couplings, coil springs are used to join the flanges either in compression or in tension between interlocking arms of the two flange members. Such a flexible coupling is shown in Fig. 10. This one as well as the couplings shown in Figs. 7 and 9 are well suited for cushioning torque

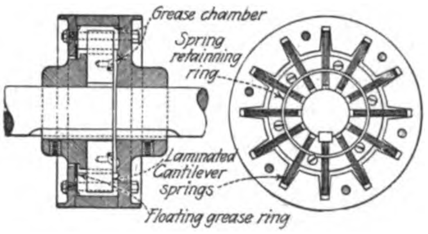


Fig. 9—Spring-type flexible coupling in which the springs form the teeth of a spur gear which meshes with an internal gear.

shocks and absorbing the back lash in a reversing drive.

The coupling shown in Fig. 7 comprises essentially two hub members keyed to the shafts, each hub having external teeth somewhat resembling a spur gear. Hairpin spring segments are interleaved in the slots between the gear teeth. These slots are wider at their adjacent ends than at their outer ends. When the load is light the spring segments contact with the outer ends of the teeth and the torque is transmitted through the spring members acting as beams. As the load increases, the spring members deflect and contact is made nearer the adjacent ends of the teeth. Under heavy loads the springs are fully deflected and the central part of the springs transmits all the torque, being subjected to almost pure shear. The deflection of the springs above mentioned requires some relative movement of one hub with respect to the other. The back lash thus introduced affords a cushioning effect as it is gradually absorbed in the springs without impact. This type of coupling permits end movement and some misalignment. It requires lubrication, being grease packed.

The fourth type of all metal coupling is that using an arrangement of gears. In Fig. 6 is shown a double-type coupling of this character that is meeting with favor. The hubs keyed to the shafts carry external spur gears. A floating sleeve, carrying internal spur gears at each end, surrounds the two hubs. The gear teeth of the sleeve permanently engage the gear teeth of the hubs. The sleeve has lateral and angular play. To correct for misalignment a sliding action takes place between the external and internal gear teeth. Lubrication is necessary for this coupling. Oil is used and is thrown to the interior circumference of the sleeve and into the gear teeth by centrifugal force. The floating member is split as in a flanged coupling. This type of coupling provides no cushioning of torque. It will withstand moderate misalignment and offset of shafts and absorbs end movement.

Closely allied to the coupling as a means of connecting the motor to its drive is the clutch. The clutch is similar to a coupling so arranged that the halves can be quickly disconnected thereby permitting part of the drive to run while the rest does not. This form of connection is particularly advantageous when the motor will not readily start the load,

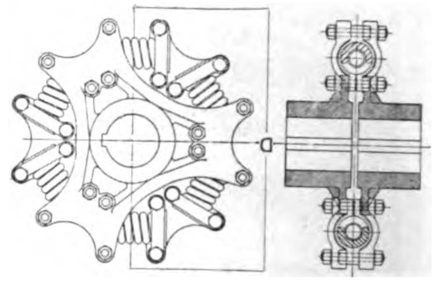


Fig. 11—Another type of spring coupling.

Coil springs under compression supply the desired resiliency and flexibility.

but will start it provided the motor can first be brought up to speed before being connected to the load.

There are many forms of clutches and cut-off couplings, but for the purpose of this article we may think of them as falling into two classes, those employing mechanical methods of engagement and those in which the friction surfaces are magnetically operated. The first class has found wide application on lineshafts, countershafts, and also on the individual driven machine. The magnetic clutch, on the other hand, has found particular favor, when used in direct connection with the motor. For this reason this discussion will be confined to the magnetic clutch.

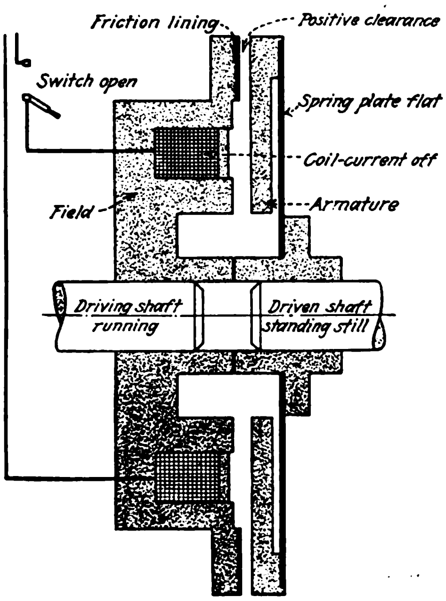
The magnetic clutch is primarily a means for readily connecting and disconnecting a motor from the driven machine, either while at rest or when in motion. The general construction of this unit is shown in Fig. 10. It consists essentially of a field or driving member and the armature or driven member. The armature is carried on a spring steel plate. This plate holds the friction faces normally out of engagement. When current passes through the winding of the field member, the armature is attracted to it, causing the friction surfaces to be engaged. The turning power of the clutch is transmitted entirely by the friction surfaces under pressure due to magnetic attraction. In accelerating a load there is some slippage between these surfaces. In some cases the clutch may be gradually applied by inserting a rheostat in the field winding circuit and gradually increasing the excitation. This permits a very smooth acceleration.

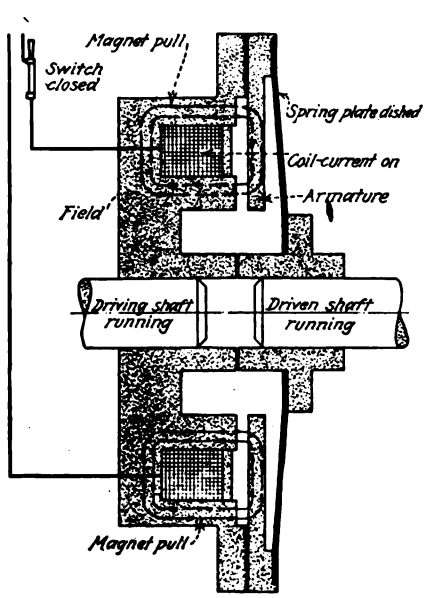
Magnetic clutches are particularly suited where frequent starting and stopping is desired and may be used in lieu of starting and stopping the motor. They permit of remote con-

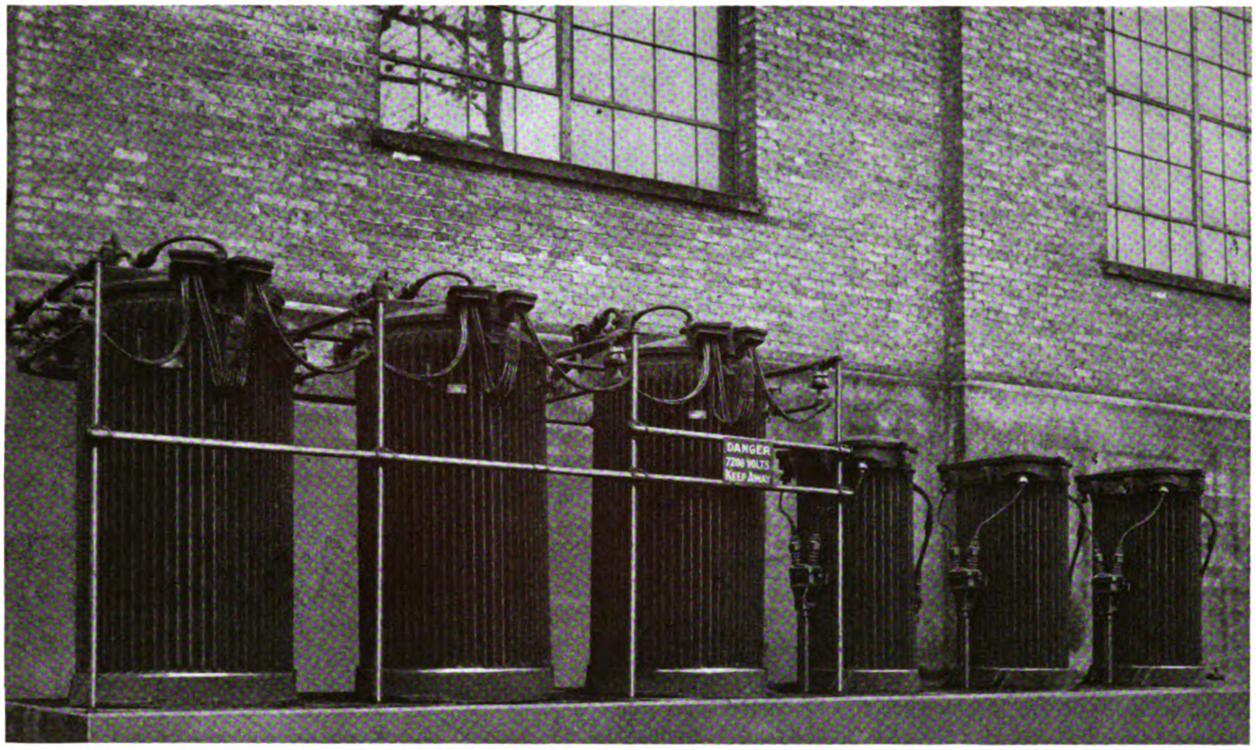
(*Please turn to page 569*)

Fig. 10—The magnetic clutch is often used to connect the motor directly to the driven machine.

The drawing at the left shows the position of the clutch parts when disengaged. In the drawing at the right, current has been applied to the magnet winding thereby attracting the armature or flange connected to the driven shaft so that the friction plates are in contact. In this way it picks up the load gradually, as it requires a short time for the magnets to become completely energized.







Delta-delta connected outdoor installation of transformers used for industrial purposes. The bank at the left has a bus for completing the low-tension connection while the high-tension connections are made through lead sheath cable connecting to buses within the building.

Connecting Transformers To Three-Phase Circuits

By L. F. GOSS
Chief Engineer, Kuhlman Electric Co., Bay City, Mich.

A discussion of the factors affecting the operation of transformers in parallel and the selection of transformers for industrial service

IN THE FIRST part of this article, which was published in the November issue, it was pointed out that to the man buying or operating industrial transformers, ever present problems are: What manner of transformer connection will best fit the requirements? How may transformers be operated in parallel? Factors that should be considered in the purchase of a transformer. Considerations affecting transformer efficiency, regulation, and power factor. In the first section of this series of two articles the question, "What manner of transformer connection will best fit the requirements?" was answered. This article will treat the remaining factors that have just been enumerated. We will first consider the operation of transformers in parallel.

The satisfactory parallel operation of transformers is definitely dependent upon five principal characteristics; that is, any two or more transformers which it is desired to operate in parallel should possess: (1) The same inherent phase angle difference between primary and secondary terminals; (2) the same voltage ratio; (3) the same percentage impedance; (4) the same polarity; and (5) the same phase rotation.

To a much smaller extent, parallel operation is affected by the relative outputs of the transformers, but actually this aspect is reflected in the third characteristic, for if the disparity in outputs of any two transformers exceeds a certain figure, it is extremely difficult to incorporate sufficient impedance (without resorting to the use of magnetic shunts) in the smaller transformer to produce the correct loading conditions for each individual unit.

Characteristics (1) and (5) given in the foregoing apply only to polyphase transformers. A very small degree of latitude may be allowed with regard to the second characteristic mentioned, while a somewhat greater tolerance may be allowed with the third, but the polarity and phase rotation where applicable, of all transformers operating in parallel, must be the same.

The theory of the parallel operation of single-phase transformers is essentially the same as for three-phase, but the actual practice for obtaining suitable connections between any two single-phase transformers is considerably simpler than the determination of the correct connections for any two three-phase transformers.

(1) *Phase angle difference between primary and secondary terminals.* In single-phase transformers this point does not arise, as by the proper selection of external leads any two single-phase transformers can be connected so that the phase angle difference between primary and secondary terminals is the same for each. Consequently the question really becomes one of polarity.

(2) *Voltage ratio.* It is very desirable that the voltage ratios of any two or more transformers operating in parallel should be the same, for if there is any difference whatever, a circulating current will flow in the secondary windings of the transformers which are connected in parallel, but before they are connected to any external load. Such a circulating current may or may not be permissible according, first, to its actual magnitude, and second, as to whether the load to be supplied is less than or equal to the sum of the rated outputs of the transformers operating in parallel. As a rule, however, every effort should be made to obtain identical ratios, and particular attention should be given to obtaining these at all ratios when transformers are fitted with adjusting taps. In passing, it may be well to point out that when a manufacturer is asked to design a transformer to operate in parallel with existing transformers, the actual ratio of primary and secondary turns should be given, as this ratio can easily be obtained exactly. Such figures would, of course, be obtained from the original manufacturer of the existing transformers.

(3) *Percentage impedance voltage.* The percentage impedance voltage, which is a factor inherent in the design of any transformer, is a characteristic to which particular attention must be paid when considering parallel operation. The percentage impedance voltage is determined by the formula.

$$IZ = \sqrt{(IR)^2 + (IX)^2}$$

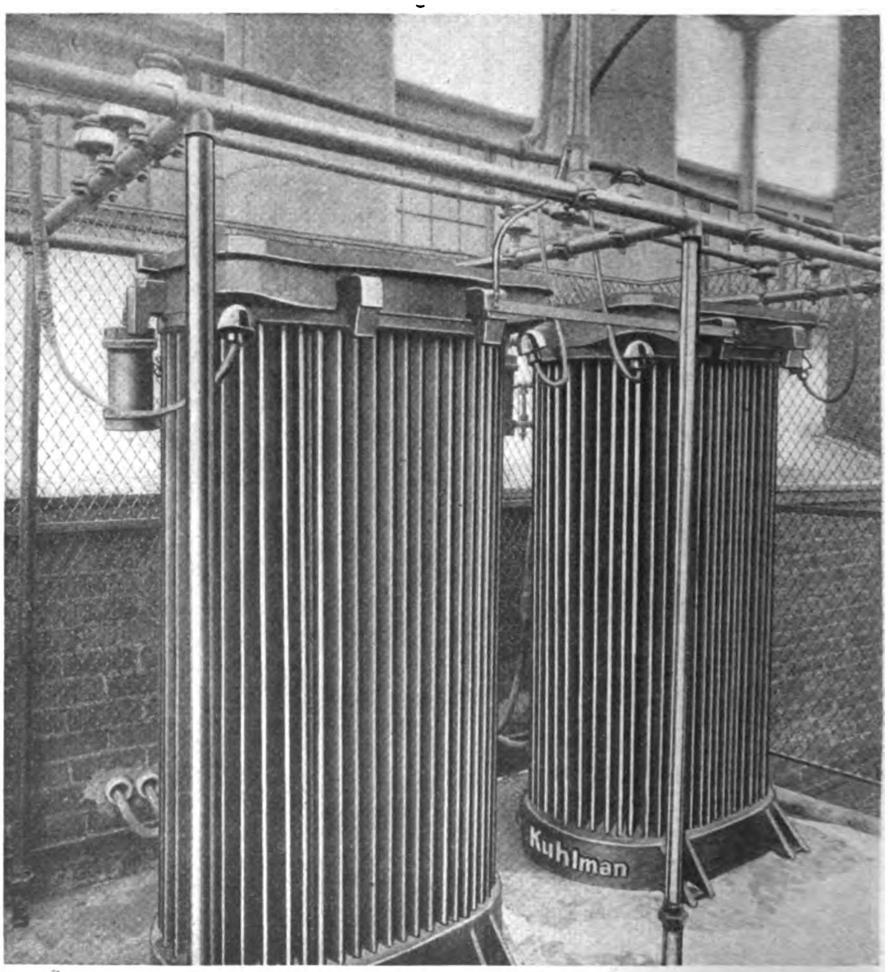
where IZ is the percentage impedance drop, IR the percentage resistance drop and IX the percentage reactance drop. The value of I is, of course, inserted to correspond with the normal full-load current of the transformer. Assuming that all other characteristics are the same, the percentage impedance voltage determines the load carried by each transformer, and in the simplest case, viz., of two transformers of the same output operating in parallel, the percentage impedances must also be identical if the transformers are to share the total load equally. If, for instance, of two transformers connected in parallel having the same output, voltage ratio, and the like, one has an impedance of 4 per cent and the other an impedance of 2 per cent, the transformer having the larger impedance will supply a third of the total bank output, and the other transformer will supply two-thirds, so that the transformer having the higher impedance will only be carrying 66 per cent of its normal load, while the other transformer will be carrying a 33 per cent overload.

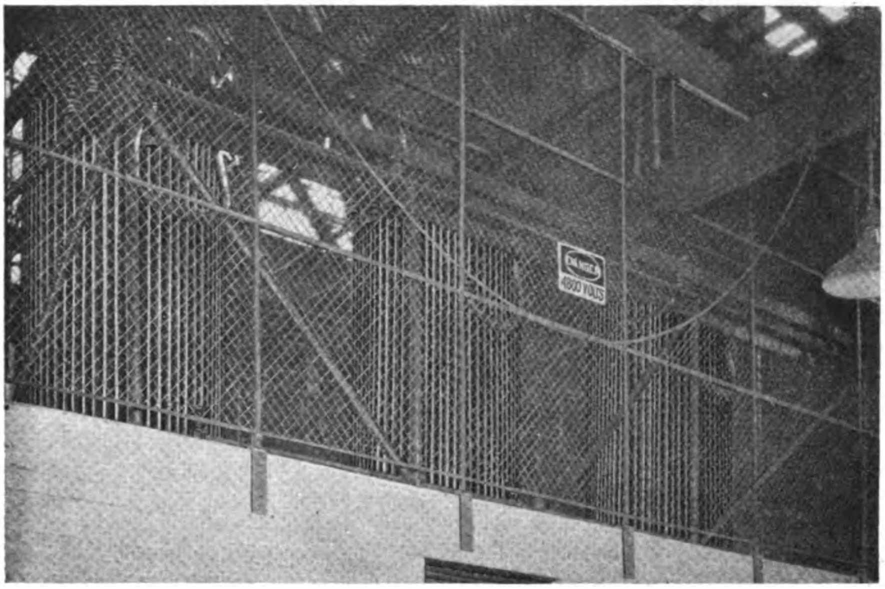
When operating transformers in parallel, the smallest transformer should not be less than one-fifth of the output of the largest, as otherwise it is extremely difficult, as mentioned above, to incorporate the necessary impedance in the smaller transformer.

(4) *Polarity.* The term polarity when used with reference to the parallel operation of electrical machinery is understood to refer to a certain relationship existing between two or more units, and it is not applied to any single unit considered alone. Any two single-phase transformers have the same polarity when their instantaneous terminal voltages are in phase. With this condition, a voltmeter connected across similar terminals will indicate zero.

Single-phase transformers are essentially simple to phase in, as for any given pair of transformers there are only two possible sets of external connections, one of which must be correct. If two single phase transformers, say X and Y, have to be phased-in for parallel operation, the first procedure is to connect both primary and secondary terminals of say, transformer X, to their corresponding busbars, and then to connect the primary terminals of trans-

Open-delta connected indoor installation of transformers at plant of Standard Brass Manufacturing Co., Detroit, Mich.





This installation transforms the power for the Detroit Copper & Brass Rolling Mills, Detroit, Mich.
It is located on a balcony in one of the mills and is screened off for protection to workmen.

former Y to their busbars. If the two transformers have the same polarity, corresponding secondary terminals will be at the same potential, but in order to ascertain if this is so, it is necessary to connect one secondary terminal of transformer Y to what is thought to be its corresponding busbar. It is necessary to make the connection from one secondary terminal of transformer Y so that when taking voltage readings there is a return path for the current that is flowing through the voltmeter.

Voltage across the disconnected secondary terminal of transformer Y and the other busbar is then measured, and if a zero reading is obtained, the transformers have the same polarity, and permanent connections can accordingly be made. If, however, the voltage measured is twice the normal secondary voltage, then the two transformers have opposite polarity. To rectify this, it is only necessary to cross connect the secondary terminals of transformer Y to the busbars. If, however, it is more convenient to cross-connect the primary terminals, such a procedure will give exactly the same results.

(5) *Phase rotation.* In single-phase transformers, this point does not arise, as phase rotation is a characteristic of polyphase transformers.

In the case of polyphase transformers special attention must be given to characteristics (1) and (5). However, let us consider all characteristics in order.

(1) *Phase angle difference between primary and secondary terminals.* The choice of suitable external connections which will enable two or more polyphase transformers to operate satisfactorily in parallel is much more complicated than is a similar choice for single-phase transformers, largely on account of the phase angle difference between primary and secondary terminals of the various connections. It becomes necessary, therefore, to study carefully the terminal connections of polyphase transformers which are to be operated in parallel before attempting to phase them in.

It should be noted that the question of phase displacement is one of displacement between the line terminals, and not necessarily of any internal displacement which may occur between the vectors representing the voltages across the individual phase windings.

(2) *Voltage ratio.* (3) *Percentage impedance voltage.* (4) *Polarity.* With polyphase transformers exactly the same remarks apply to these three items as was outlined for single-phase transformers.

(5) *Phase rotation.* When phasing in any two or more transformers, it is essential that both their polarity and phase rotation should be the same. The phase rotation may be clockwise or counter-clockwise, but so long as it is the same with both transformers, the direction is immaterial. It is generally advisable when installing two or more transformers for parallel operation, to actually make a test for the purpose of definitely ascertaining that corresponding secondary terminals have the same instantaneous voltage magnitude and phase.

Considerations Affecting the Selection of Transformers

The outstanding features of a transformer, which should receive careful consideration by the prospective purchaser are, reliability, iron loss, copper loss, and impedance.

(1) *Reliability.* In both design and manufacture, the reliability of a transformer should be given first consideration. The principal factors bearing on reliability are: sound mechanical construction; liberal oil ducts and electrical clearances; current and induction densities sufficiently low to avoid excessive local heating; liberal radiating surfaces; and good oil, preferably of the non-sludging grade.

All these factors tend to increase the first cost of a transformer, and the first three tend to reduce the efficiency, but these disadvantages are outweighed by the saving in cost of repairs and the advantage of insuring continuity of service.

(2) *Iron loss.* The iron loss of a transformer should be reduced to a minimum since this loss is constant and continuous during the whole of the time the transformer is connected to the mains. While, however, a low iron loss is undoubtedly a great advantage, it should not be obtained at the expense of a very high copper loss, and thereby the probable sacrifice of reliability.

(3) *Copper loss.* It should be remembered that the operation of a commercial transformer of given proportions and for a given output entails the loss of a certain and fairly constant total amount of power, consisting generally of iron and copper losses. Acceptance of this statement implies, therefore, that if the iron loss of a commercial transformer is very low, the copper loss will be correspondingly high and vice versa. A high copper loss may represent a distinct menace to the coil insulation on account of the possibility of excessive undetermined local heating occurring in the interior of the coils, and therefore it is far sounder practice to design for a closer agreement between copper and iron losses than to aim for a very low iron loss at the expense of the copper loss or of the electrical or thermal design of the transformer.

(4) *Impedance.* The effect of impedance upon regulation is important

as a high impedance entails a high regulation at the lower power factors. High regulation as such is certainly an undesirable feature, but it must not be overlooked that a reasonably high impedance is the best protection against the damage a transformer is liable to sustain due to external short circuits. In deciding, therefore, what impedance a transformer should have, reliability and safety should be given preference. In this connection, the question of parallel operation is of importance, since the impedance of a transformer which has to operate in parellel with an existing transformer should be equal to the impedance of the latter. When, however, such an impedance is too low for satisfactory service under modern conditions, it is better to insert separate impedance coils in series with the existing transformer, than to perpetuate a design which is no longer in accordance with sound modern practice.

Determining Regulation of Transformers

Efficiency—The losses in a transformer comprise the iron and the copper losses and sufficient power is consumed at the primary terminals of the transformer to supply both the load and losses. The relation between the load W plus the losses w to the load W is the efficiency.

$$\text{Per cent efficiency} = [W \div (W + w)] \times 100$$

Given a 200-kva. transformer with a core loss of 744 watts and a copper loss of 2,350 watts, the full-load efficiency will be

$$[200{,}000 \div (200{,}000 + 744 + 2{,}350)] \times 100 = 98.6 \text{ per cent}$$

The core loss remains constant irrespective of the load, but the copper loss varies as the square of the load.

The copper loss in the above example at three-quarter load will be:

$$(0.75)^2 \times 2{,}350 = 1{,}332 \text{ watts.}$$

The efficiency at this load will then be:

$$(0.75 \times 200{,}000) \div [(0.75 \times 200{,}000) + 1{,}332 + 744] \times 100 = 98.7 \text{ per cent.}$$

The core loss is not affected by temperature, but the copper loss increases as the temperature increases, and all guarantees are made on the basis of 75 deg. C.

Regulation—The regulation of a transformer is affected by both impedance watts, or copper loss and by reactance. In any transformer some of the lines of force, instead of going through the iron, leak through the coils. This leakage flux generates an opposing voltage called reactance volts in the coils which reduces the delivered volts under load, and this is especially noticeable in loads of low power factor.

The delivered volts on a non-inductive load, that is a load consisting of resistance only, will be reduced by the following amount from what would be expected from the turns ratio alone.

$$\text{Per cent regulation} = qr + [(qx)^2 \div 200]$$

where qr = per cent impedance watts, also called IR drop

and qx = per cent reactance volts.

As an example let us calculate the delivered volts under full load for a 200-kva., 2,300/230-volt transformer having 2,350 watts copper loss and 3 per cent reactance volts.

The impedance watts qr will be equal to the copper loss divided by the full-load rating of the transformer, or $qr = (2{,}350 \div 200{,}000) \times 100 = 1.175$ per cent.

$$\text{Per cent regulation} = 1.175 + (3^2 \div 200) = 1.22 \text{ per cent.}$$

The actual delivered volts from the above transformer with a non-inductive load will be:

$$(100 \text{ per cent} - 1.22 \text{ per cent}) \times 230 = 227.2 \text{ volts.}$$

All standard regulation guarantees are based on a load at 80 per cent power factor and the formula for regulation at power factor m and reactive factor n, is:

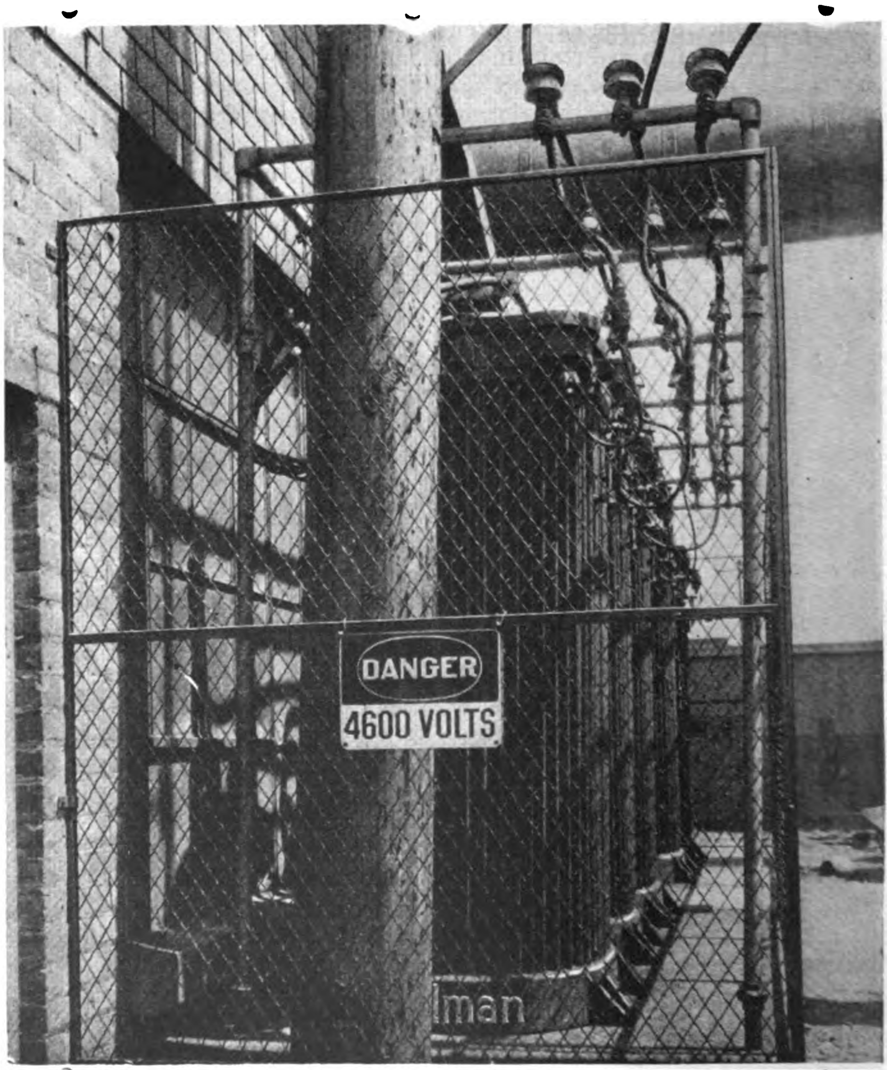
$$\text{Per cent regulation} = m \times qr + n \times qx + [(m \times qx - n \times qr)^2 \div 200]$$

Assume the same transformer as in the preceding example operating with a load at 80 per cent power factor and the corresponding 60 per cent reactive factor. In this case the per cent regulation at full load will be:

$$\text{Per cent regulation} = 0.8 \times 1.175 + 0.6 \times 3 + [(0.8 \times 3 - 0.6 \times 1.175)^2 \div 200] = 2.75 \text{ per cent.}$$

The actual delivered volts under this load will be:

This outdoor installation transforms power received at a 4,600-volt potential for the Detroit plant of the Federal Bearing & Bushing Co.



(100 per cent — 2.75 per cent) $\times$ 230 = 223.6 volts

Power Factor—In a direct-current circuit the volts $\times$ the amperes = watts, but in an alternating current circuit that has any inductance, such as motors, the volts $\times$ amperes will not equal the watts as indicated on a wattmeter, but will give a result that is greater than the actual watts. The relation between these two is the power factor of the circuit, and is expressed by the following equation:

$$[\text{watts} \div (\text{volts} \times \text{amp.})] \times 100 = \text{per cent power factor.}$$

If the watts equaled the volt-amperes, the power factor would be 100 per cent and the circuit would be non-inductive.

Assume a load of 150 kw. having a power factor of 80 per cent. The transformer capacity required to carry this load will be:

$$150 \div 0.8 = 187.5 \text{ kva.}$$

The nearest standard size is 200 kva. and this size should be used.

Exciting Current—The item of exciting current is considered of importance by some especially where there are a large number of distribution transformers on the system under a part time load. This is the current that flows in the primary when there is no load on the secondary and has a very poor power factor. The volt-amperes of exciting current or apparent watts consists of the core loss and a little copper loss due to the exciting current, both of which are power components, and the magnetizing current, which is out of phase.

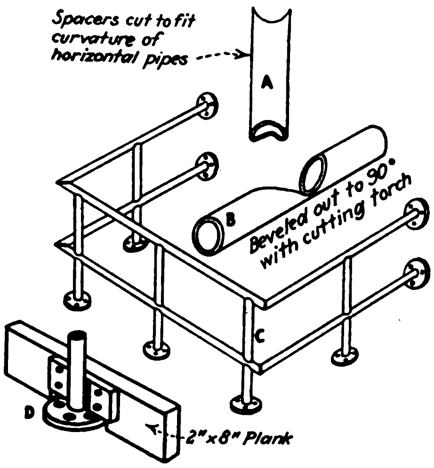
The exciting current is principally objectionable as it causes line loss and requires some generator capacity to supply. While it is impossible to eliminate it entirely, modern transformer design tends to reduce it.

Method of Fabricating All-Welded Pipe Railings

A LARGE Eastern shop desired to have a 2-in. pipe railing built on very short notice. It was found that there were no railing fittings of the desired size available; so their welding department was asked to do the job. The result was most pleasing to the officials of the plant, and the method of construction, as stated in the *Welding Engineer*, is one that can be used wherever welding is available.

As shown at *C* in the accompanying diagrams, all of the pipe used was of short length. No patterns of any kind were necessary, and the only tools that were used besides the torches were a square, a hammer, a centerpunch, a pair of dividers, and a vise.

In making up a railing the corners of the railing are formed by cutting a large V at the desired point, as shown at *B* in the diagram, care being taken not to cut all the way through the pipe. The pipe is then bent at right angles, the joint very carefully squared and lined up, after which it is tack-welded.



These diagrams show the principal steps involved in building a welded pipe railing.

The spacers, shown at *A* in the diagram, are all cut off in the pipe cutting machine or with the torch, a great deal of care being taken to see that they are all of the same length, and the ends are all notched out to fit the curvature of the horizontal railings. To assemble the railing, lay the top horizontal rail, that has already been bent and tack-welded, on the floor, and measure off and mark where the spacers are to go. After squaring up the spacers, in all directions, with the top horizontal rail, tack-weld the spacers into a vertical position, tacking securely enough so that the pipe will stand considerable handling. Lay the bottom horizontal railing on the floor, turn over the top rail that has the spacers welded to it, so that the spacers point downward, and place the lower end of the spacers on top of the railing that is on the floor. Line up this railing with the spacers and, after checking with the square, tack-weld the spacers to the rail.

The floor flanges are made of ¼-in. boiler plate and are cut to a 5-in. diameter. The bolt holes are four in number and are ½ in. in diameter. The flanges are cut with the cutting torch. The holes are drilled and the edges of the plates are cleaned before the legs of the railing are welded to them. The legs are made in the same way as the spacers, except that one end of the legs is left square. The square end of the leg is tack-welded to the floor plate and the leg in turn is tack-welded to the railing, after the railing has been turned upside down. After all tacking is done, the railing is turned right side up and a neat welding job is done on all joints, care being taken to see that all joints are square and in line with other parts. The wall flanges can be welded last.

Sketch *D* in the diagram shows a method of attaching a kick board to a railing. These kick boards are required by a good many safety engineers and are used at the bottom of a railing which is around an overhead platform or a pit. These boards prevent tools and other objects from being kicked onto workers below.

The plant mentioned above has built both kinds of railings, the threaded fitting railing and the all-welded railing. In both cases the pipe used was old and useless for any other purpose. Cost figures showed, however, that the welded railing could be built at about half the cost of a similar railing of the same length in which tees, crosses and elbows were used.

Flexible Couplings for Motor Drives

(Continued from page 564)

trol and easy application. They provide a ready and quick means of mechanical disconnection and are therefore frequently applied as a safety feature. They are frequently used to permit starting a motor without load, the clutch being energized after the motor has attained normal speed. This practice applies particularly to synchronous motors. They are mechanically simple, normally balanced and may be used for higher speeds and heavier duty than other types of clutches. They do not require lubrication.

Where magnetic clutches are installed as a safety provision, a magnetic brake is generally provided in conjunction, to stop the machinery after the motor is disconnected.

Practical pointers on

Mush or Hit-and-Miss Armature Coils

with details of the procedure employed in obtaining the data needed in making up these coils in the different types used in motor windings

THIS is the first of a series of articles that will deal with the types of coils that the average repair shop will use in the repairing and rewinding of motors and generators. The subject will be treated in such a manner as to enable the average repair shop to make up the simple and inexpensive tools required to make coils for a single job, along with hints and ways to increase production on coils made in large quantities. Practical details will be given for each type of coil now commonly used and the ways they can be employed in different types of a.c. and d.c. windings.

By A. C. ROE
and
D. H. BRAYMER
Consulting Editor, Industrial Engineer

IT IS a recognized fact that well-shaped coils and good insulation properly applied are the foundation of any electrical winding used in the stator or rotor of a rotating machine. Therefore, it is obvious that the useful life of the repaired machine depends upon the skill and knowledge of the coil maker. The broader this man's experience and knowledge of windings as applied to a.c. and d.c. machines, and also of wire and insulation, the better will he be able to develop a coil and insulate it for any type of machine brought in for repairs.

By a knowledge of windings is meant the winding rules, types and connections of electrical windings, such as lap and wave, for a.c. and d.c. machines. Actual experience in repair work will in many cases enable a winder to simplify a difficult job by changing the type of winding.

The making of coils from a repair shop standpoint is considerably different from the manufacturer's viewpoint. The motor manufacturer develops special tools and trains a certain group of employees to make one type of coil in large quantities. In some cases the routine handling of coils through the various manufacturing steps may require one or more operations that would be unnecessary in the average repair shop. The repair shop, on the other hand, has to make a number of different types of coils every day with the tools on hand and a small force of workers. In every case, therefore, the cost and number of special tools for any one set of coils must be kept to a minimum. This forces the average repair shop to train a small force to be all-around coil men who can wind, pull, tape and perform all of the details of coil making.

Here is where the repair shop is fortunate, for young men or boys taking courses in night schools can be trained to make coils and thereby get training that later will enable them to wind small motors or medium-sized a.c. stators or d.c. armatures. A repair shop is a fine school for any man or youth who desires to go into any branch of electrical work. Electrical apparatus of all kinds is brought into the average repair shop, from the coffee percolator to large rotary converters, while transformers and other equipment that is too large to be taken to the shop, is repaired in the field where service conditions can be observed and studied at first hand.

The average young man, after spending 12 or 18 months in making coils, has a practical respect for coils and insulation in general and knows what skinned spots on wire and chafed insulation on a coil mean. With such knowledge he is in a far better position to judge where extra insulation is required and when and where to use special care in the winding and handling of complete machines.

The repairing of electrical apparatus can be divided into two distinct and separate parts, as follows: (1) The repair shop that caters to the plants in the surrounding district and repairs electrical machines of all makes and types. (2) The repair shop located in an industrial manufacturing plant whose one and only function is to repair the motors and other electrical equipment for this one plant only.

In many instances both these repair shops have an advantage over the electrical manufacturer. The manufacturer must develop a standard range of motors for 110, 220, 440, and 550 volts and in some cases, as with induction motors, the windings are designed so that the motors can be carried in stock rated at 220 volts, and reconnected for 110- or 440-volt operation, or other schemes may be used to reduce stock and tools and provide straight-line production.

When a motor or other piece of apparatus has been purchased for a definite purpose and its voltage is fixed, this works out to the repair shop's advantage in some cases and is the basis for the statement already made that the coil man should know something about the construction of a.c. and d.c. motors and generators. The following cases will illustrate this point. Assume that a 220-volt induction motor is up for repairs and the stator is to be rewound. After checking the coils used we find it requires 54 turns of one No. 15 d.c.c. wire and 72 mush coils. The coil man on checking the winding data finds that the motor was connected two-parallel star for 220 volts. He then advises the shop foreman to change the connection to series-star for 220 volts, as he will wind the

coils with 27 turns of two No. 15 d.c.c. wires in hand. This will save 27 turns on each coil, reduce the labor, and provide a satisfactory winding.

Or again, the coil may be one that is wound with a small size of wire with the wires arranged in layers and the coil well shaped. It may have 20 turns of one No. 18 d.c.c., four wide by five deep for a voltage of 110 d.c. Here the coil man sees a chance to change to a flat, mush type of coil using No. 18 single-cotton and enamel-covered wire.

A good coil man checks each job from the coil back to the complete machine for opportunities to save time and improve the winding. For instance, a check on a d.c. machine revealed that the brush-holders could be shifted 45 mechanical degrees. This helped to eliminate a mean bottom lead connecting job and also stopped the brushes from sticking in the bottom brush-holder box.

Ribbon wire can be used to replace three or more round wires in parallel, and numerous other combinations can be made to save time on a rewinding job when it is properly studied and handled.

The industrial plant that does its own rewinding can save in this department by standardizing on one or a small number of different makes, types and standard ratings of motors. This will reduce spare parts to a minimum and the repair shop can handle its coil and rewinding work to better advantage, as a slight change might make one coil suitable for a number of other motors, thus calling for a large quantity of one kind of coil.

Mush Coils—By the term "mush" is meant coils not wound in layers and sometimes called "hit-and-miss" coils. The wires are allowed to pile up by winding slowly back and forth across the wire space or winding room on the mold. When winding mush or hit-and-miss coils, care should be taken not to allow the wire to make a sudden cross from one side of the mold to the other.

The mush coil is frequently used in both a.c. and d.c. machines and its use is increasing. With improvements in insulation and types of wires, the use of mush coils will be further increased and, therefore, this coil is worthy of considerable study.

In order to avoid repetition of information already presented, readers are referred to the information on coils that has appeared in the following issues of INDUSTRIAL ENGINEER: (1) Diagrams for Coil Winders, by A. C. Roe, page 283, June, 1922, issue. (2) Shop Practice and Details of Coil Making Methods, by A. C. Roe, July, 1922, issue. (3) Methods for Laying Out Coils for D.C. Armatures and A.C. Stators, by A. C. Roe, page 159, April, 1922. These articles give considerable coil data and details of card records and how to lay out coils.

The keeping of coil records is one of the important items in repair work and the system used must be flexible and simple. The coil data should be tied in with an order number and the name of the customer, in commercial shops, and with the motor type and serial number in industrial plant repair shops.

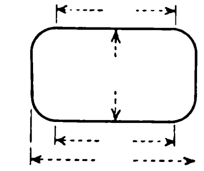


FIG.7

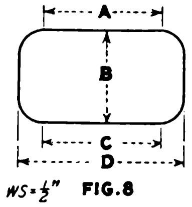


FIG.8

COIL NO	A	B	C	D	NO OF COILS
1					
2					
3					
4					
5					
6					

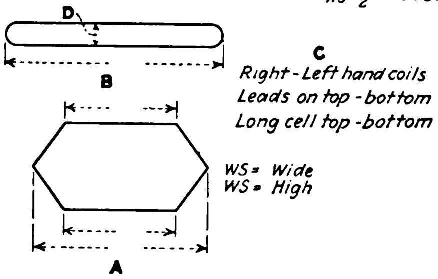


FIG.9

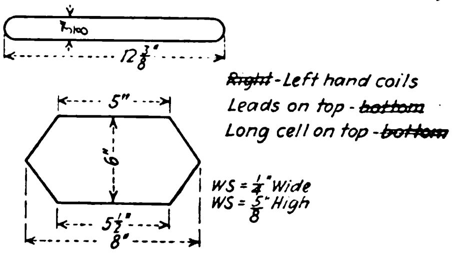


FIG.10

Figs. 7 to 10—Diagrams that can be used for recording dimensions and lead positions for mush coils of the concentric-chain type used in single-phase motors.

Fig. 7 shows a skeleton diagram providing spaces for dimensions. Fig. 8 shows this diagram for use with a table in cases where a number of different sizes of coils are used. Fig. 9 illustrates the diagram that can be used for mush pulled coils providing dimensions for the winding loop and notations for the type of coil. Fig. 10 shows Fig. 9 filled in for a left-hand rotor coil with the leads on top, the long cell on top, and the leads brought out on the end of each cell in the winding slot.

Figs. 1 to 6—Diagrams that can be used for recording dimensions and lead position for mush coils.

Fig. 1 shows a skeleton diagram that can be made up as a rubber stamp and filled out as required. Fig. 2 shows the diagram in Fig. 1 filled out for a flat, diamond-mush coil with leads at the diamond point. Fig. 3 is filled out for a flat, rectangular mush coil showing the position of the leads. Fig. 4 is filled out for a flat mush coil of a basket winding, showing the diamond points off the center line of the coil. Fig. 5 is filled out for a flat, diamond-mush coil for a d.c. machine having the leads at the end of each slot side. Fig. 6 shows a diagram providing for dimensions when the center of the diamond points is off the center line of the coil.

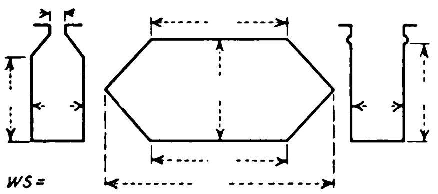


FIG.1

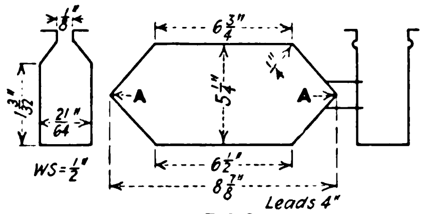


FIG.2

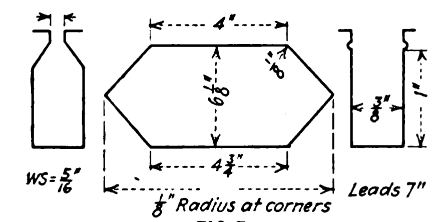


FIG.3

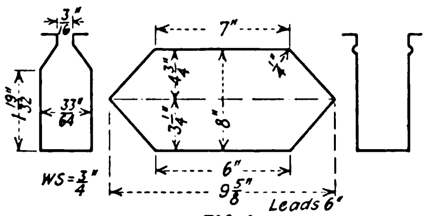


FIG.4

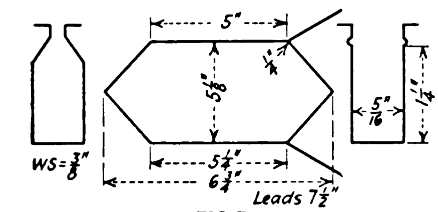


FIG.5

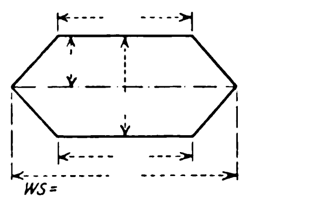


FIG.6

WINDING TAG

Order No. Xy - 9682
Customer John Doe Co.
No. Coils 48 Mould No. 18
Type Mush Ins. —
Size Wire #17 S.C. and En
Turns Per Single Coil 27
Coils Wound From No. 2 Reels
Color Sleeving 1 Wires Per Sleeve 2
Leads Start 4 Finish 4
Notes Tape ends 3/4"

Fig 11

WINDING TAG

Order No. 4200
Motor No. 60 Series No. 1278910
Type XT Make MR
H.P. 5 Volts 220 Amp 13.1 Phase 3
Cycles 60 R.P.M. 1750 Poles 2
Conn. Series Y Pitch 1 and 11
No. Coils 24 Mould No. 6
Type Bip Ins. —
Size Wire #15 S.C. and En
Turns Per Single Coil 4-3
Coils Wound From No. 2 Reels
Color Sleeving 2 Wires Per Sleeve 1
Leads Start 6 Finish 6
Notes
Tape all around
.0045 x ½ cotton — Don't
dip

Fig. 12

Fig. 11—Winding card containing coil information for commercial repair shops where a variety work is done. Fig. 12—A similar winding card for use in an industrial plant repair shop.

Both of these cards are filled out to show the data that would be recorded for a particular job.

The systems described in the above articles cover the subject and the following will add a few more practical points. Fig. 1 shows a diagram that can be used for all flat, mush-wound coils regardless of lead position or whether the coils are diamond-shaped or rectangular. This diagram can be made up as a rubber stamp and the sketch stamped on 3-in. by 5-in. or 4-in. by 6-in. cards, or on forms carrying other motor rewinding data.

The sketch of the partially closed and open slot can be filled in to give the slot size. The letters *W.S.* indicate wire space, and is the thickness of the center block of the mold. The other dimensions necessary for flat mush coils are, length of cells or slot portions of coil, total over-all length, width or coil pitch in inches, location of diamond point and radius used at corners of mold, wire space and location of and length of leads.

Fig. 2 shows the diagram in Fig. 1 filled in for a flat, diamond mush coil with leads at the diamond point. This coil is used for a partially-closed slot machine, the slot opening being ⅛ in., with the radius in corners ¼ in. *W.S.* is ½ in. and the length of leads 4 in. The one dimension for the coil width indicates that the diamond points *A* are on the center line of the coil. The letters *A* are not included in the coil data. They have been used in this case to illustrate the point referred to.

Fig. 3 shows the diagram of Fig. 1 filled in for a flat, rectangular mush coil, such as is used in d.c. bipolar machines using the staggered winding. Note the two straight lines that have been drawn across the coil width, and the position of the leads. In this case the over-all length is not filled in as the cell lengths are also the length of the mold, as shown.

Fig. 4 shows the same diagram filled out for a flat mush coil for a basket winding. Note the method of locating the diamond point, which is off center ⅜ in., and the location of the leads between the long cell and diamond point. In this type of coil, which is used in basket windings for stators, the long cell is the bottom cell. This is just the reverse in two-layer windings, the reason being that the bottom of the basket coil must be bent down to allow the top coils to clear.

In Fig. 5 the diagram of Fig. 1 is filled out for a flat, diamond mush coil for a direct-current machine having the leads at the end of each cell.

A slightly different diagram is shown in Fig. 6, which provides for off-center diamond points and does not include the slot size sketch. This reduces the cost of the stamp and permits the use of a smaller card.

Fig. 7 shows a diagram used for mush coils of the concentric-chain type, such as are used in single-phase motors, etc.

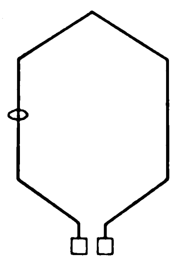


FIG.13
1-Turn, Single Coil
Lap Winding

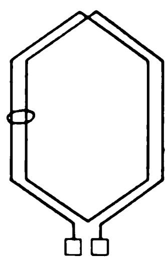


FIG.14
2-Turn, Single Coil
Lap Winding

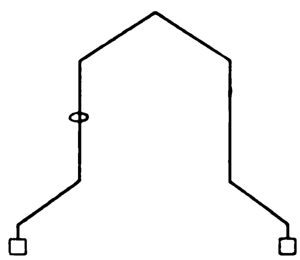


FIG.15
1-Turn, Single Coil
Wave Winding

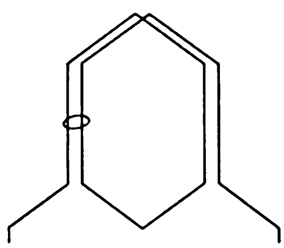
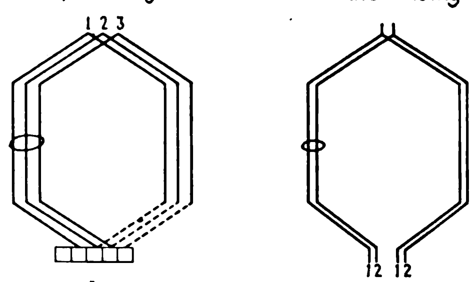


FIG.16
2-Turn, Single Coil
Wave Winding



A
3 Single Coils
per Cell

FIG.17

B
2 Single Coils
per Cell or
Winding Unit

Figs. 13 to 17—Diagrams showing different types of single coils as used in lap and wave windings.

Fig. 13 shows a one-turn single coil for the lap winding of an a.c. or d.c. machine. Fig. 14 is a two-turn, single coil for a lap winding. Fig. 15 is a one-turn single coil for a wave winding. Fig. 16 shows a two-turn single coil for a wave winding. Fig. 17 shows a winding unit composed of three single coils and one or two single coils per cell. The small circle surrounding one coil side indicates that the conductors enclosed are all in the same slot.

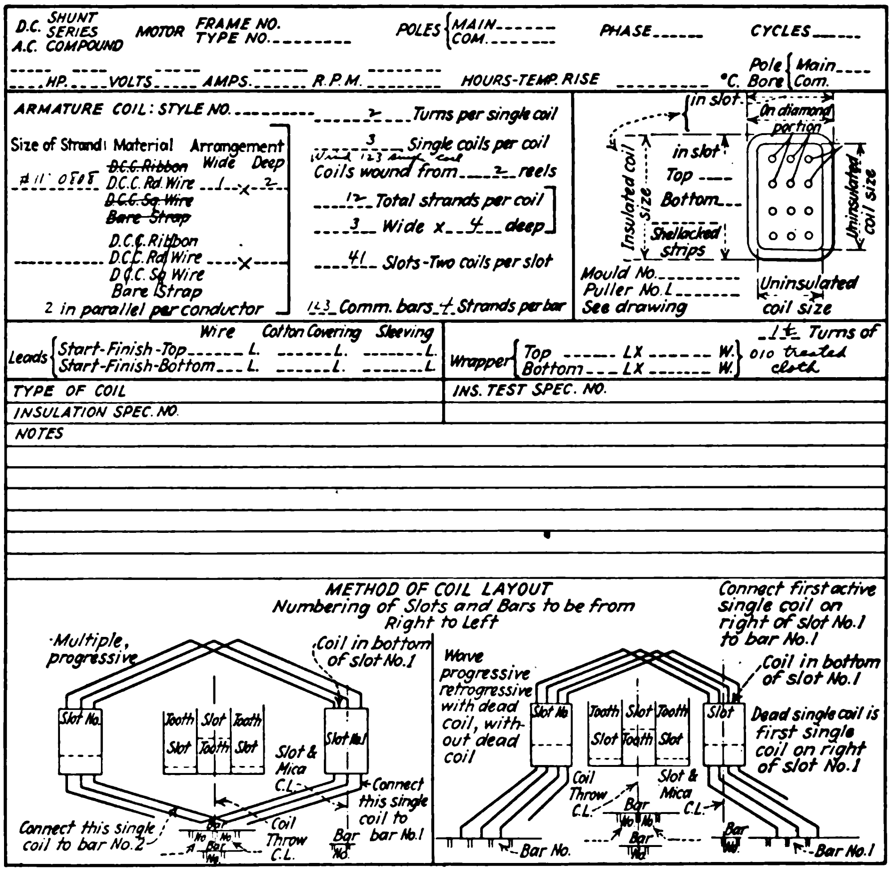


Fig. 18—This form provides a means of recording complete coil and armature winding data.

The top part of the form is filled out as it would be in a particular case.

Fig. 8 shows the same diagram except it has a table providing for the recording of six different sizes of coils. This is a better diagram than Fig. 7 when this type of coil has a number of different sizes of coils per group. The last column indicates the number of coils of each size required.

In Fig. 9 a diagram for mush, pulled coils is shown. The part *A* is similar to Fig. 1. The loop *B* is for recording the length of the loop over the outside of the pins, and also the diameter of the pins, at *D*. At the right of this diagram the notation is used to indicate the lead position, whether the coils are right- or left-handed, and also whether the long cell is on top or on the bottom. By crossing out the words not wanted, this notation can be used in all cases.

In Fig. 10 the diagram of Fig. 9 has been filled in for a left-hand rotor coil with leads on top and long cell on top, with the leads brought out from the end of each cell. Note the way the leads are shown both on the loop and the pulled sketch. The over-all length of 8 in. is measured from inside edge of diamond point.

Fig. 11 shows a winding card suitable for commercial repair shops. The reverse side can be used to give coil dimensions, by using the diagrams in Figs. 1, 6, 7, 8, or 9, according to the type of coil needed. Fig. 12 shows a winding card that will be found useful in the winding department of repair shops in industrial plants. This differs from Fig. 11 in that the motor data are given, and also the connection and coil pitch.

The card in Fig. 11 is shown filled in for a flat, diamond-mush coil. The data indicate that the coils are wound with 27 turns of two No. 17 s.c.e. wires in parallel. The number of reels gives the number of wires in hand. The wires per sleeve is also the number of wires in parallel per single coil. The number of colors of sleeving is a multiple to use to determine the total number of single coils. In this case it is, 24 coils × 1 = 24 single coils. In Fig. 12, 24 coils are shown and two colors of sleeving or, 24 × 2 = 48 single coils or bars.

Fig. 12 is filled out for a flat mush coil having 48 single coils. In this case 24 single coils are wound with four turns and 24 single coils with three turns, there being two wires in hand and one wire in parallel per single coil. The three and four turns are obtained by winding three turns with two wires in hand, and

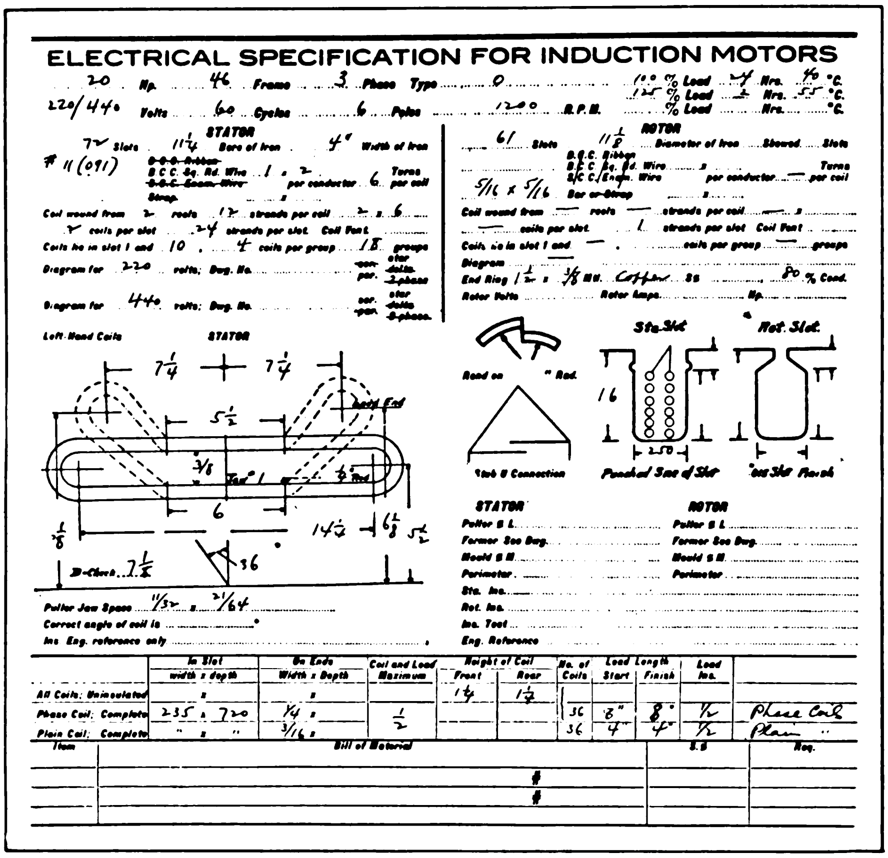


Fig. 19—This form provides for all necessary data needed in connection with induction motor coils and types of windings.

The form is filled out for a 220-440-volt winding on a three-phase, 60-cycle, 1,200-r.p.m. induction motor.

then cutting one wire and putting on the fourth turn with one wire. A red sleeve should be used for the start and finish of the four-turn coils. This enables the armature winder to connect the leads to the commutator in the proper sequence: namely, 3, 4, 3, 4, etc.

Before describing other types of mush coils, winding terms and methods of checking them will be defined.

Conductor—This will be considered as a single wire or bar. A conductor may also be composed of a number of adjacent wires or (strands) in parallel. For example, a flexible cable consisting of 40 No. 19 wires is a conductor, and each single No. 19 wire is a strand; or the cable is a conductor having 40 strands in parallel.

It is important to get the full meaning of the term conductor, since this represents the total current-carrying medium of any one single coil. This conductor may be a single round or square wire, a ribbon wire or a number of wires in parallel; hence the reason for expressing the conductor for each single coil as the number of wires per sleeve.

Strand—This can be defined as a single unit or wire of a conductor. Consider a single coil wound with 15 turns of three No. 14 d.c.c. wires in parallel. In this case the conductor is three No. 14 wires and the strand is one No. 14 d.c.c. wire.

Single Coil—This can be defined as any one coil having one or more turns of any size conductor. Fig. 13 shows a one-turn, single coil for a lap winding, a.c. or d.c. Fig. 14 shows a two-turn, single coil for a lap winding, while Fig. 15 shows a one-turn single coil for a wave winding, and Fig. 16 shows a two-turn single coil for a wave winding. The small circle surrounding one coil side indicates that the conductors enclosed are all in the same slot.

From the rules given above it should be understood that a single coil can be wound as 27 turns of two No. 14 wires in parallel, or the coil can be wound from two reels, with two wires per sleeve. If the winding data read "27 turns, No. 14 d.c.c. wire, coils wound from two reels, one wire per sleeve," this would mean that we have *two single coils* per cell or winding unit and that each single coil consists of 27 turns of one No. 14 d.c.c wire. This brings us to the meaning of the term "winding unit."

Winding Unit—The winding unit, or number of single coils per cell, may be defined as consisting of a number of single coils assembled or wound together. This group of single coils is taped together so that the armature winder handles a number of single coils as one unit; hence the term winding unit, or single coils per cell. Fig. 17*A* shows a winding unit composed of three single coils, and Fig. 17*B* shows a winding unit of two single coils per cell.

Fig. 18 shows a form suitable for recording complete coil and armature winding data. The sketch in the upper right-hand corner is used to indicate the arrangement of the wires in the complete winding unit, as well as to give the uninsulated and insulated coil sizes. The data as filled in are self explanatory.

The section for leads uses the terms, "start, finish," and "top" and "bottom." This ties in the coil winder's terms with the armature winder's terms for the coil leads. The coil winder thinks of leads as starting and finishing ends while the armature winder thinks of these as top and bottom leads.

Thus, when the coil man is checking the first coil made for the armature winder, if the top lead is too long he knows that this is his starting lead, etc. This form can be used to give complete data on d.c. machines and for single-phase, commutator, series-type armatures.

Fig. 19 shows a form suitable for recording induction motor coil and winding data.

Another section of this article, to appear in an early issue, will deal with methods for winding and shaping mush coils.

Using Non-Metallic Gear Drives

(Continued from page 553)

determine the laws governing the behavior of non-metallic gear teeth so that a formula for use in computing designs can be worked out. Another advantage, irrespective of the strength, is the increased life of both the non-metallic pinion and its mating gear, due to decrease in wear.

The accompanying illustration on page 550 gives a fair idea of the standard construction of non-metallic gearing which has been recommended and generally adopted for gear and pinion construction. The keyway is cut through the gear material with the endplate, where used, as an additional support. On light service the endplate is not necessary. On gears made up of compressed layers of fiber the flange or endplate extends entirely to the tip of the teeth, as is the case with rawhide pinions. Idler gears are bushed. Gears cut from solid board do not require support at the tip of the teeth.

All of these fabric-base, non-metallic gears may be used for practically any industrial service within their rating. Reversing service is probably the most severe and before using them on such service it is advisable to consult with the manufacturer of the product and obtain his advice. Also, it is undesirable to have two non-metallic gears mesh together as it is not only unnecessary, but is uneconomical from a cost standpoint. Both gears wear more rapidly than when in contact with a metallic, cut-tooth gear.

The manufacturer of these products will give instructions for machining the gear teeth, that is, cutting speeds and so on, and will also furnish tables showing the recommended rating per inch of face for gears of various pitches and number of teeth of different peripheral speeds in feet per minute. These tables are too long to be reproduced here.

Fabric-base pinions must be lubricated with practically the same frequency as is necessary for metal-to-metal gears. For this purpose a paste composed of 20 per cent graphite and 80 per cent liquid shellac or a stiff paste of graphite and vaseline or machine oil is recommended. Any good graphite grease will be satisfactory if its viscosity is sufficient to maintain a film over the surface of the tooth. One manufacturer has put out a self-lubricating, non-metallic gear material which it has graphite impregnated in it.

EDITOR'S NOTE: Acknowledgment is made to the following companies for illustrations and information used in the preparation of this article: Bakelite Corp., New York, N. Y.; Boston Gear Works, Norfolk Downs, Mass.; Continental Fibre Co. (Contex), Newark, N. J.; the Chicago Rawhide Mfg. Co., Chicago, Ill.; Diamond State Fibre Co. (Celoron), Bridgeport, Pa.; Fibroc Insulation Co. (Fibroc), Valparaiso, Ind.; Foote Bros. Gear & Machine Co., Chicago, Ill.; Formica Insulation Co. (Formica), Cincinnati, Ohio; General Electric Co. (Fabroil, Textoil, and Textolite), Schenectady, N. Y.; Horsburgh & Scott Co., Cleveland, Ohio; National Vulcanized Fiber Co., Wilmington, Del.; and Westinghouse Electric & Mfg. Co. (Micarta), East Pittsburgh, Pa.

I'm looking for information and I'm willing to pay for it*

THERE is an old saying to the effect that, so far as his life work is concerned, no one can stand still—he must either progress or go backward. This is just another way of saying that when one stops going forward he starts to go backward, and the truth of this applies to business organizations and nations fully as well as to individuals.

Consequently, it is a good thing to sit down occasionally, say once a year or so, and sort of take stock of ourselves both as to our personal affairs and from the standpoint of our accomplishments as busy men who have very definite and indispensable duties to perform in the operation of that enormous machine which we call Industry.

Every year we spend many millions of dollars for new equipment to build new plants, increase production, or replace damaged or obsolete equipment. At the same time we are constantly testing and experimenting to find the best tools and methods of accomplishing certain desired results. And so the end of each year finds, or should find, us a little closer to our goal, and with a greater stock of information based on the results of our work. Furthermore, each of us has learned a good many things that other operating men would like to know, and could use to good advantage.

I want to find out what you have been doing and the results you have obtained; so the Editors have authorized me to offer several prizes for the best records of accomplishment.

Here's the story

EVERY reader of INDUSTRIAL ENGINEER is invited to tell what he has done within the past two years to cut operating and maintenance costs, improve operating conditions, solve operating problems, increase production: in other words, what worthwhile improvement have you made and what are the results obtained from it?

A first prize of $50 will be paid to the one who sends in what the Editors consider is the most helpful and striking record of what has been done. A prize of $25 will be given for the next best account, and a prize of $15 for the third. Letters which do not win prizes will be considered for publication at our regular rates.

IN JUDGING the manuscripts neither length nor style of writing will be considered, nor will the amount of savings made necessarily be the deciding factor. The awards will be based on the general value of the results obtained, from the standpoints of the savings made and the improvement in operating conditions, the soundness of the idea, the ingenuity with which it was conceived and executed, and its applicability to other industrial plants.

For example, you may have improved operating conditions by changing from individual drive to group drive, or *vice versa*, or made a saving by replacing obsolete electrical or mechanical power drive equipment with more modern and efficient devices that reduce labor and require less maintenance.

Perhaps you have saved time and money by eliminating troublesome and expensive production delays due to poor or improperly applied operating equipment.

Again, you may have cut maintenance and repair costs by putting in better testing and repair equipment, so that you can detect troubles before they become serious, and do better repair work.

Or possibly you have effected worth-while economies by changing your methods of scheduling and handling the work, so that a better job can be done with greater efficiency.

These are only a few of the ways in which plant operation has been improved and operating costs reduced.

Make your story brief and concise, but go into enough detail to show clearly what the previous conditions were, what changes were made, the cost of these changes, the savings made, and the general nature and value of the results obtained. If you can send photographs to illustrate your story, do so. The contest closes Jan. 7, 1927. Address all letters to Contest Editor, INDUSTRIAL ENGINEER, McGraw-Hill Publishing Company, Tenth Ave. at 36th St., New York, N. Y.

HERE is a good chance to win a prize and help other plant men by giving them the results of your experience in solving important problems that are of mutual interest. Check over what you have accomplished and then send in your story—NOW.

Practical Pete

***$50 for the best record of accomplishment.**
$25 for the next best record.
$15 for the third best record.

INDUSTRIAL ENGINEER
Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories
G. A. VAN BRUNT, *Managing Editor*

Light Utilization Has Lagged in the Parade of Progress

IF WITH one eye we view in our imagination the tremendous improvement in light production during the past century and with the other eye we view the progress in light utilization, it becomes evident that the former has outstripped the latter. As much light can be purchased now for one or two cents as could be bought a century ago for a dollar, assuming no change in the purchasing power of money. On this basis the workman should have at least 50 foot-candles upon his work today, for his predecessor a century ago certainly had no more than 1 foot-candle. (The latter would be the illumination supplied by an ordinary candle upon a surface one foot distant and perpendicular to the direction of the light rays.)

As a matter of fact the average worker of today is supplied only a few foot-candles. The purchasing power of money is now only a fraction of what it was a century ago. Furthermore, the standards of living and working are at present much higher than they were a hundred years ago. These last two reasons might well demand an increase of five or ten times in the quantity of light upon the work.

Taking all these factors into consideration we might conclude that work places at the present time should be illuminated to an intensity of several hundred foot-candles, if lighting is to have its proper place in the parade of progress.

There would be no point to this argument if lighting indoors were up to the level which is economically possible and optically desirable. However, it is far below the best level, and its progress has been inhibited by a lack of appreciation of the foregoing. The situation is the more inexcusable because it has been definitely proved that good lighting not only pays for itself in greater production, reduced spoilage, increased safety, and better morale, but, in addition, usually pays very good dividends.

Money Well Spent May Be Money Saved

IN THEIR attempt to make what they consider is a "good showing," operating executives sometimes fall into the error of hesitating, or refusing, to spend any money for new equipment or other betterments until it becomes absolutely necessary to do so. Frequently the management either fosters or is responsible for this attitude.

However it originates, the inevitable result is that obsolete or worn-out equipment is patched up and carefully nursed along year after year in the effort to keep it in service long after it should have been junked. When compared to the price of a new piece of equipment, the cost of one repair job may not be very large. Nevertheless, when the total cost of the maintenance attention required over a period of two or three years is added up, the result may be interesting, if not pleasing. Furthermore, this does not take into consideration the cost of production delays that have been occasioned by shutdowns due to failure of the equipment, nor the savings in labor or increases in production that could be made without difficulty by the use of up-to-date and more efficient devices.

True economy in the expenditure of time, money, labor or any other thing of value is highly commendable and should be practiced at all times. However, refusal to spend money for new equipment that will save labor, increase production, or cut operating and maintenance costs is by no means economy. Nor does the way of economy lie in neglecting equipment now in use until failure makes extensive repairs imperative.

The most expensive man around a plant is not necessarily the one who spends the most money in discharging his duties properly. In the long run, the most expensive man is likely to be the one who causes his employer to spend a dollar, while he is trying to save 75 cents by neglecting to keep the equipment under his care in good condition, or continuing to operate it after it has outlived its period of real usefulness and becomes a liability rather than an asset.

Are You and Your Men Taking Advantage of the Public Library?

RECENTLY, a prominent plant engineer who has a force of several hundred men under his general direction stated that so many of his men stop studying and learning more about their work that he has difficulty in obtaining a properly trained supervisory force with sufficient technical knowledge.

This executive, like many others with a similar problem, encourages his men to take correspondence or night school work and to read the technical or trade journals and books covering their activities and industry. As a result, practically every man who has had a technical education or two years of correspondence or night school work has the equivalent of a foreman's position, or better.

In addition to these schools the advantage which the local public library offers should not be overlooked. Practically all of our cities and industrial centers have public libraries whose resources are free to all and which offer a path to education that need not exclude any other activity, but which may accompany it and make it more valuable. Self-education by this means need not be pursued in any set or rigid form, but may be obtained as fast or as slowly as each individual desires, or time

and energy permit, and be as specialized or general as needed.

One of the important directions of growth of the public libraries of our cities has been in the development of scientific, technological and economic divisions. These departments are, in many cases, staffed by technical experts. The public library can be a valuable guide to the modern worker and executive seeking an acquaintance with those fields of knowledge essential to an understanding of, and wide participation in, our industrial society of today.

There are, of course, many books and periodicals which these men should receive and own, but much special information is often required for reference that the average man needs and does not feel that he can afford to purchase.

The thinking operating executive who is looking to the future will do well to call this source of free information to the attention of his staff, and may find that he, too, can use it profitably.

Make a Plant Engineer Responsible for All Equipment

THE vice-president of an old and nationally-known organization recently made the following statement: "A few weeks ago I hired a Plant Engineer and have given him complete charge of the electrical and mechanical equipment in our plant. I am paying him a mighty good salary, but if he does not pay his salary twice over in savings, I shall be very much surprised. A Plant Engineer is one of the best investments that any plant can make."

The executive whose words are quoted above has come up through the operating end, and made an enviable record in the capacity of Plant Engineer for several large firms, before his present connection. His views on plant operation can be accepted as those of an authority.

Every industrial plant of any size contains a large amount of electrical and mechanical equipment that must be inspected, kept in good condition, and occasionally shifted around. Every year a certain amount of this equipment has to be replaced, for one reason or another. Again, in most plants new equipment is continually being purchased to increase productive capacity.

All this work naturally brings up a thousand and one operating problems and questions that must be investigated and answered correctly, or trouble and loss of efficiency will be the result. In addition to this more or less routine work, there is a constant need for special investigations and studies bearing on the application and operation of equipment under the conditions obtaining in each plant.

No executive who is trying to handle all of these details along with other important work can hope to make a good job of it. Nor does the rather common practice of making one man responsible for the electrical equipment and another for the mechanical, always work out to the best advantage.

Shifting of responsibility and arguments arising from the conflict of individual preferences and opinions do not make for high operating efficiency and freedom from serious operating troubles. These conditions can be avoided, however, by centering responsibility for all equipment in one man, and holding him accountable for operating results.

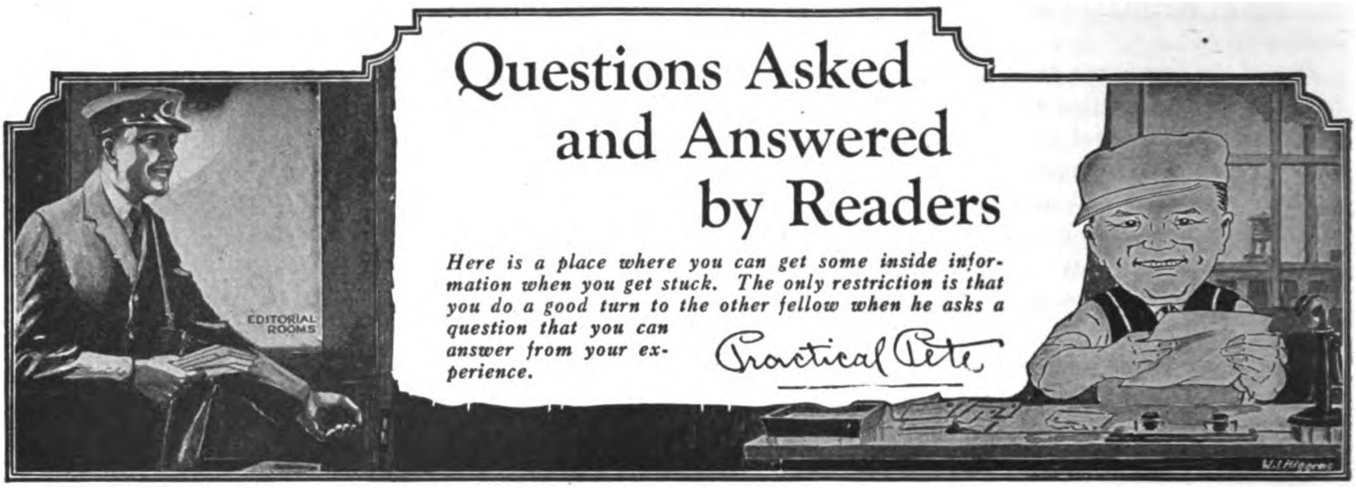
Building a Force of Assistants for Future Plant Programs

IN REPLY to a question on how he quadrupled his force within a few months, the Electrical Engineer of one large industrial plant recently said:

> Each of my assistants in charge of the different construction and maintenance gangs has been promoted from the ranks. Several years ago I saw that, eventually, the entire plant must be reconstructed, which would mean a lot of work for my department over a period of several years. To have a supervisory force trained in our methods and practices when that time came was my big problem. Therefore, I encouraged the men to take up night or correspondence school work, and urged the technically-trained men in my department to pursue their studies further. The most promising individuals were shifted about, to give them wider experience.
>
> In addition, each man was urged to ask questions on anything he did not understand, and to offer suggestions on his work. My first assistant or I held frequent conferences with these men on general subjects and would even stay after hours to explain technical questions or company problems, when the explanation would be too lengthy to give during working hours or was of particular interest to only one or two men. Especially were we careful not to create that high and mighty attitude of superiority which some so-called executives think is so necessary to preserve their dignity.
>
> In other words, our problem was not to demonstrate that we were boss—the men knew that—but to help and encourage them to do and learn more. Our method has evidently proved successful because these men are most enthusiastic in carrying on for us and we are getting the work done the way we want it, which might not be the case if it had been necessary to obtain foremen and other assistants from the outside.

There is a good deal to think about in the words of this plant executive. First, the true executive carefully distinguishes between having men work *with* instead of *for* him, and he recognizes that this is obtained only through his attitude toward the men. Also, many other industrial plants must face similar problems of rehabilitation to bring an old plant into shape to meet present-day competition.

Industrial operating executives upon whom this task will fall should be laying their plans for this work, with particular attention toward how they are going to build their force. Wire, conduit, motors, belts, pulleys, lineshaft and the other supplies necessary can be purchased when needed. The men who are to supervise the details of these rehabilitation programs cannot be so easily obtained. The best are usually developed through careful training and coaching in the plant in which they are working.



Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Practical Pete

Who Can Answer These?

Rotor Winding of Slip-Ring Motor—I am changing the stator winding of a 35-hp., wound-rotor induction motor from three phase to two phase. Will it be necessary to rewind the rotor of this motor? If so how should I go about laying out the new winding and what form should it take? If it is unnecessary to change the winding, please tell me the reason therefore.
Los Angeles, Cal. B. K. W.

• • • •

Type of Valve Best Suited for Long Service.—I would like to know whether a gate valve, a globe valve, or a changeable disk valve is best suited for long service when used in the following applications: (1) Cold water at ordinary water pressure. (2) Low-pressure hot water. (3) Low pressure steam. (4) Steam at pressures ranging from 100 to 250 pounds. I will greatly appreciate any information that readers may give me in this regard.
Ilion, N. Y. M. M.

• • • •

Effect of Altitude on Capacity of Generators.—Will some reader tell me the effect of altitude above sea level on the capacity of electric generators? We often contract to install electrical apparatus at altitudes of about 12,000 ft. above sea level and would like to know how much the generators should be derated. The A.I.E.E. Standardization Rules specify derating in regard to temperature guarantees, but we would like to know the equivalent in capacity as expressed in kw. or kva. rather than in temperature rise.
Lima, Peru. A. B.

• • • •

Manipulation of Wire Cables—I am in charge of the electrical and mechanical maintenance of a large plant and because of this I have considerable to do with the elevators in the plant buildings. I feel the need of more information regarding the manipulation of wire cables as used on elevators, hoists, and cranes. Specifically, I would like detailed information on how to go about recabling an elevator or crane hoist, including directions for shackling, seizing, and resocketing. Any hints or kinks that readers can give me regarding the methods of handling steel cable around the equipment mentioned will be very much appreciated.
St. Paul, Minn. D. H. C.

• • • •

Method of Removing Wires From Semi-Closed-Slot Motors.—I shall appreciate it very much if some of the readers will tell me the best way to strip the stators of small series motors having semi-closed slots. I have seen a great many repair shops burn the insulation so that the wires come out easily. Does this in any way damage the iron or the insulation between the laminations? Can you advise me of a better method? Also, I should like to know the number of dippings and bakings that are necessary to make a first-class job on a motor.
Rome, Ga. M. S. C.

Heating of Fan Motor—I have rewound a 16-inch desk-fan motor, using a coil span of 1-and-3 instead of the former coil span of 1-and-6, and using the same number of turns, coils, and size of wire as formerly used. The motor now operates at a normal speed of 1,750 r.p.m., but becomes abnormally hot within a few minutes after starting. Most of the heat seems to come from the stator iron rather than from the coils themselves. What is the cause of this and how can it be corrected, keeping the present 1-and-3 slot winding? The motor is of the split-phase type, having four poles, 24 slots, and 24 coils with 58 turns of No. 24 single cotton-covered enameled wire per coil. It is rated at 110 volts, 60 cycles. The original winding had a coil span of 1-and-6, 83⅓ per cent pitch. I shall greatly appreciate any information that readers may give me on this problem.
St. Louis, Mo. T. A. B.

• • • •

Effect of Doubling Speed of Lineshaft.—We have a lineshaft operating at 250 r.p.m., driving a number of woodworking machines. I am considering doubling the speed of this lineshaft; that is, increasing it to 500 r.p.m. This will give a better belt drive from the motor to the lineshaft, as then I will not need to use so small a motor pulley. Also, a number of the pulley ratios from the lineshaft to the jackshaft will be changed, as I am going to increase the speed of most of the machines only about 30 to 50 per cent instead of doubling them. There is no noticeable vibration in the lineshaft at present. As nearly as I can determine from computations, however, the shaft is well loaded at the present time and I should like to know what the effect will be when I increase the speed, and whether I might have to put in a new shaft, assuming that the present shaft is carrying full normal load for its size and speed. I shall greatly appreciate any information that readers may give me on this problem.
Milwaukee, Wis. G. G. K.

• • • •

Can Two Single-Phase, Watt-Hour Meters Be Connected to Measure Three-Phase Power?—I should like to know whether two single-phase, watt-hour meters can be connected so as to measure three-phase power. If so, will some reader explain the method of connection to use. I have already connected these watt-hour meters in the same manner as is used with two single-phase wattmeters in the two wattmeter method of measuring power. With this connection I find that at unity power factory both meters run at equal speed, while as the power factor gets lower one meter will slow down and the other one speed up until at 50 per cent power factor one meter stops entirely while the other is running at double speed. If the power factor is lowered below 50 per cent the meter that has stopped will reverse and run in the other direction. I wish some one would explain the reason for this, and tell me why the meters are affected differently instead of being affected in the same manner. Specifically, I should like to know what takes place in each meter at unity power factor, at 75 per cent, at 50 per cent, and at 25 per cent power factor.
Montreal, Can. W. T.

Answers Received To Questions Asked

What Size of Belt Is Required for This Drive?—A 15-hp., 1,750 r.p.m. motor is used to drive a punch press. The pulley on the motor is 6 in. in diameter and the driven pulley is 40 in. in diameter, the distance between centers of the motor and press pulleys being 15 ft. I wish readers would give me some information regarding the adaptability of leather belts to this drive. Specifically, what width of leather should be used to give the best results? Should this belt be single or double-ply? Would you advise the use of some other type of belt and if so, what kind and why?
Rockford, Ill. R. W. A.

In regard to the question asked by R.W.A., handbooks state that under good conditions of operation a belt drive can be designed for an effective tension of 55 lb. per inch of width, in case a good grade of single leather belting is used. R.W.A.'s condition of service could not be classed as good, however, because the diameter of the shaft pulley is quite large compared with the 6-in. motor pulley. The ratio of the diameter of the two pulleys on a belt drive should not be greater than 6 to 1 for ordinary service. Therefore, a more satisfactory belt drive would result if it were designed by using a tension of 45 lb. per inch of width.

The size of belt to use is determined as follows: To calculate the belt speed for a pulley, multiply the diameter of the pulley in inches by 3.1416 and then multiply by the number of revolutions per minute of the pulley; this is to be divided by 12 to get the speed in feet per minute. Substituting in this formula the data as given by R.W.A.:

$$(6 \times 3.1416 \times 1{,}750) \div 12 = 2{,}750 \text{ f.p.m. approximately.}$$

The width of the belt required to transmit 15 hp. is determined by the formula: $W = (33{,}000 \times \text{hp.}) \div (S \times E)$. Substituting gives $(33{,}000 \times 15) \div (2{,}750 \times 45)$ = approximately 4 in. as the belt width. In this formula hp. equals horsepower transmitted; S equals belt speed in feet per minute; E equals the effective tension in pounds per inch of width. I believe that a single-ply, 4-in. belt should be used because a double-ply belt would be too stiff to wrap well around the pulley. If a belt does not wrap well on the pulley, the effective pull is reduced and if loaded up to its full capacity it is likely to slip.
E. E. SIGEL.
Robertsdale, Pa.

Without going into detail concerning the computations incidental to determining the proper size of belt for R.W.A.'s punch press drive I had estimated that a 4-in. single belt made of special, mineral-tanned leather should be used. The advantage of using special, mineral-tanned leather is that this material is highly elastic and yet does not slip, which makes it ideal for punch press work. Single-ply leather is usually preferable wherever it can be used because it will transmit more power per dollar of first cost, as well as having a lower ultimate cost.

However, I decided to ask a belt engineer for his opinion on this drive. He said that on a drive such as described there is considerably less than 180 deg. arc of contact on the 6-in. pulley. Also, the belt must be capable of withstanding the shock and acceleration encountered in punch press service. In addition, all motors are capable of carrying a 50 per cent overload so as to withstand these momentary shock loads. Therefore, he states that it stands to reason that a 4-in. single belt is out of the question and that nothing less than a 5-in. double belt should be used. I believe that these two opinions will indicate to R. W. A. the difficulty incidental to specifying a belt drive according to book formulas without considering the operating service.

Newark, N. J. W. F. SCHAPHORST.

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In his question R.W.A. has not given complete data and consequently in discussing it, it is necessary to assume certain factors; namely, that the drive is horizontal and the tight side is on the bottom strand.

The first comment we would then make is that the 15-ft. center distances is certainly maximum for the width of belt which would be required. Also, the pulley ratios are high. The 6-in. driving pulley is small for the drive and so does not give a large amount of belt surface in contact on the driving pulley. Because of the operating characteristics of the punch press, other concessions, or allowances, are necessary also.

Our recommendation for the belting of this drive would be a 6-in. double leather belt, approximately 16/64 in. thick. In suggesting this width of belt, the efficiency correction for the drive and the overload capacity of the motor, as well as the operating characteristics of punch presses. are taken into consideration. CLAUDE O. STREETER.

Mechanical Engineer,
Graton & Knight Co.,
Worcester, Mass.

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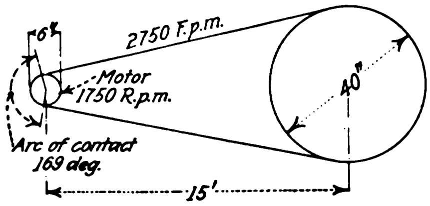
The accompanying drawing shows the transmission layout for R.W.A.'s punch press problem, in which he asks about the drive leading from the motor. The exact location of the motor, whether on floor, ceiling or a wall bracket, does not affect the case. [NOTE: Where the center line of the drive is at an angle of over 40 deg. from the horizontal allowance must be made in computing the power transmitted, particularly when the small pulley is located below. — EDITORS.]

Two methods of obtaining the solution are possible. The first, and simplest, is to use the width of belt for which the press pulley was intended. Thus, if the press pulley has a 7-in. face, a 6-in. belt would be installed. It is safe to assume that the maker of the press equipped it with a pulley of such size as would be ample to power it up to the safe capacity of the machine. Also, it was his duty to supply the press with a flywheel of such weight and diameter as would carry the



This shows the layout of the drive for a punch press, under the conditions given

peak load without undue slippage of the belt.

The second solution is obtained in a more theoretical manner. A 6-in. pulley on a 1,750-r.p.m. motor drives the belt at about 2,750 f.p.m. That is a definite starting point and the other calculations have to do with that belt speed, the effective tension of a belt at that speed, and the arc of contact on the motor pulley. Every handbook and practically all belt makers' catalogs give tables from which this data may be selected, once the layout has been plotted as per the accompanying drawing and the belt speed determined by calculation.

Formulas will obtain the same results but are somewhat slower than the use of tables. The following discussion contains the answer to the problem without going into methods.

The allowable "effective tension" for a belt at 2,750 f.p.m., as given in my tables, is 67 lb. per inch of width, when the arc of contact on the small pulley is 180 deg. The effective tension is the pulling power of the driving or tight side of the belt minus the tension in the loose side. This tension should not be so high as to stretch the fibers to any serious degree. By tables or formulas, the arc of contact on the motor pulley is found to be only 169 deg. and this lessens the grip of the belt. So, taking the factor for 169 deg. (which is 0.97) the safe effective tension is 0.97 × 67 lb., or 65 lb. per inch of width for ordinary 16- to 18-oz. single-ply leather belting of good grade.

From the above data, the width of belt to use is easily determined by the formula which gives the width as the result of dividing the product of the horsepower and 33,000 by the product of the effective tension and the belt speed. The result in this case is 2.75 in.; hence, a 3-in. belt could be used.

Insofar as the kind of belt to use is concerned, the best of satisfaction, I believe, would be obtained from a first-quality leather belt. If this belt is not cut from the plant stock, the purpose for which it is to be used should be stated when ordering the belt. Probably a belt maker would recommend a wider belt, say 3½ or 4 in. It is better to be over-belted than under.

The data given for the problem are rather insufficient. Just why a 15-hp. motor is used is not stated. It may be that this is a spare motor on hand, or perhaps the manufacturer of the punch press recommended that size. If the machine is a new one, undoubtedly the motor size has been given and all related parts are adapted to the work. If the punch is second hand, there may have been alterations in flywheel and pulley sizes that would make a good deal of difference in the size of belt required.

If the stroke of the punch were given, with information on the amount of work, whether cutting or forming and what size, then it would be a simple matter to check up the flywheel size and speed and see if it were carrying its share of the belt's load.

DONALD A. HAMPSON.

Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

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The problem confronting R. W. A. is a good example of where an allowance must be made for the peak load or overload. I would say that a 4-in. double leather belt of second-quality leather would be good enough. A 6-in. pulley at 1,750 r.p.m. gives a belt speed of approximately 2,800 f.p.m. A load of 15 hp. can be transmitted at a belt speed of 2,800 f.p.m. and with pulley ratio of approximately 1:7 by a first-quality single ply leather belt 4 in. in width.

However, as the 40-in. pulley is large and heavy the strain on the belt comes when starting the machine, and for this reason I believe that a double belt would be better than a single. A belt should be chosen which has good adhesion because it would be needed to prevent slipping when starting the heavy press.

R. W. A. can obtain a copy of a celluloid speed chart of the slide-rule type which answers this and similar problems providing that the man who works the chart will take into consideration and make allowance for overloads and peak loads. This chart may be obtained from the Leather Belting Exchange, Philadelphia, Pa., or from any leather belt manufacturer who is a member of the Exchange.

Also R. W. A. can solve his problem by using the two charts which were published on page 270 of the June, 1925, issue of INDUSTRIAL ENGINEER. If he does not have a copy of this issue on file, he will find the same table in Bulletin R-13, published by the Leather Belting Exchange, Philadelphia, Pa., which is also available from leather belt manufacturers who are members of the Exchange. By consulting the charts opposite page 24 in Bulletin R-13, he will see that a light double belt at 2,800 f.p.m. transmits 6.53 hp. per inch of width. Because of the operating conditions this would have to be multiplied by 0.74 as a factor which gives the actual rating under these conditions of 4.8 hp. per inch of width. It would not be necessary to

use the best quality of leather belt (which is cut from the hide in the section next to the backbone), as second-quality leather belt (cut from strips next to the first-quality belting) will have a power-transmission capacity of 19.2 hp. for a 4-in. belt, which is plenty to allow for the peak load. In addition, this belt would have an overload capacity of at least 50 per cent or more. We do not believe that a high-priced belt would be absolutely necessary on this drive as long as it is of good quality double leather. J. R. HOPKINS.
Chicago Belting Co.,
Chicago, Ill.

* * * *

R. W. A. could use the following short, practical method of determining the width of a leather belt required for a given horsepower which, however, does not take into consideration the centrifugal force on high-speed belts. Single leather belts 1 in. wide operating at 800 r.p.m. develop 1 hp. with a belt contact of a 180 deg. on the pulley. On this basis the width W equals: $W = (\text{hp.} \times 800) \div (V \times K)$, where hp. = horsepower of motor or power to be delivered; V = speed of belt in feet per minute; thus, $V = (1{,}750 \times 6 \times 3.1416) \div 12 = 2{,}750$ f.p.m. approximately. K = factor depending upon arc of contact taken from the accompanying table.

Belt Contact Degrees	Factor K
×180	1.0
×157.5	0.92
×135	0.84
112.4	0.76
90	0.64

The arc of contact A is obtained approximately by the formula: $A = 181 - [60\ (D\text{-}d) \div L]$; where D = diameter of large pulley in inches; d = diameter of small pulley in inches; and L = distance between pulley centers in inches. Therefore, $A = 181 - [60 \times (40\text{-}6) \div 180] = 169.7$ deg. The nearest value of K from the table is 0.92. Then $W = (15 \times 800) \div (2{,}750 \times 0.92) = 4.73$ in. A 5-in. belt would be used.

Oak-tanned leather belting is most generally used for driving punch presses. Although better results are obtained by using narrow, thick belts, as compared to wide, thin belts, it is not advisable to operate double belts around pulleys less than 12 in. in diameter. E. H. LAABS.
Engineering Department,
The Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

* * * *

The following is my solution of R. W. A.'s problem. The first step is to determine the speed of the belt in feet per minute by the formula: (3.14 × diameter of pulley in inches × r.p.m.) ÷ 12 = (3.14 × 6 × 1,750) ÷ 12 = 2,748 f.p.m., or approximately 2,750 f.p.m. The next step is to find the arc of contact of the belt on the smaller pulley thus: 180 — 4.75 (difference in diameter of pulleys in inches ÷ center distance in feet) = 180 — 4.75 × (34 ÷ 15) = 180 — 10.69 = 169.31 deg. or approximately 170 deg.

The allowable effective tension per inch of width of single and double belts of different thicknesses, with 180-deg. arc of contact as taken from the "Standardized Belt Manual," Bulletin 102, issued by The Graton & Knight Mfg. Co., Worcester, Mass., is given in the following table.

Single Leather Belts

Thickness in 64th of of an in.	Effective Tension in Lb. per in. in width
7-10	44
10-12	49.5
12-14	44
Double Leather Belts	
16-18	70.4
19-21	79.2
22-24	88.

The problem now consists of selecting a weight or thickness of belt which my experience would lead me to believe is satisfactory for this drive, and then checking this selection by substituting the value of the tension and other data in the formula to determine width.

From my experience I would assume that a 12-14/64-in. single leather belt could be used. The allowable effective tension is 55 lb. per in. in width with 180-deg. arc of contact. A smaller arc would permit less effective tension. In this case the usable effective tension would be approximately 55 × (170 ÷ 180) = 51.9 lb.

The width of such a belt is determined by the formula, Width = (33,000 × horsepower transmitted) ÷ (effective tension in pounds per inch of width × speed of belt in f.p.m.) = 33,000 × 15) ÷ (51.9 × 2,750) = 3.48 in. wide. I would use a 4-in. single leather belt 12-14/64 in. thick. I do not know the width of the pulleys, but if they could take a wider belt it might be well to repeat the computations with a thinner single belt because the thin belt would work more satisfactorily over the small pulley. The belt should be at least 1 in. narrower than the face of the pulley.

The Graton & Knight "Standardized Belting Manual" gives many helpful rules and formulas on leather belts and belt drives. W. P. IWEN.
Iwen Box & Lumber Co.
Pine Island, Minn.

* * * *

In reply to the question of R. W. A. I offer the following solution: Correct belt application depends upon several factors; namely, speed, thickness, width, the arc of contact between the smaller pulley and the belt, the material of which the belt is made, and the kind of pulleys employed. The speed of a belt for ordinary purposes should range from 3,000 to 5,000 f.p.m. The operating speed in this case is determined by the formula: $(3.1416 \times d \times s) \div 12$, where d = diameter of motor pulley, and s = speed in r.p.m. of motor pulley.

For rugged service with 15-ft. pulley centers a double belt is preferable to a single belt. The width must be great enough to stand the pull of the load and be narrower than the pulley face. For pulleys of the above-mentioned dimensions the arc of contact is ample to minimize slipping. Leather should prove adaptable for a punch press drive and will be the material considered in these calculations.

A simple formula that is usable for most belt problems is as follows: $W = (33{,}000 \times \text{hp.}) \div (P \times V)$, where hp. = horsepower; V = belt velocity; P = effective pull per inch of width. For single belts, use P as 35 lb. per inch in width, while for double belts 70 lb. may be allowed. $V = (\pi \times d \times s) \div 12$ or $(3.1416 \times 6 \times 1{,}750) \div 12 = 2{,}748.9$ or, for practical calculations, 2,750 f.p.m. Substituting this value in the formula for width we have: $W = (33{,}000 \times 15) \div (70 \times 2{,}750) = 2.57$ in. Instead of using a 2½-in. double belt I would use the next size larger which would be a 3-in. double belt.
Schenectady, N. Y. JOHN B. RAKOSKE.

* * * *

Where Should I Use This Kind of Wire?—Most manufacturers of wire for use in house wiring and in industrial plants make three kinds of wire: a Code wire, an intermediate grade and a 30 per cent rubber compound grade. I should like to learn from other readers whether they use all three grades around their plants and if so, the basis on which they decide the grade that shall be used for a certain application. Do you find any of these grades unsuited for industrial plant use? I shall appreciate any information that you can give me regarding the proper application of these three grades of wire.
Newark, N. J. B. S.

In the October issue of INDUSTRIAL ENGINEER there is given an answer to a question asked by B. S., regarding different kinds of insulation of wire and the conditions under which each should be used. I do not agree with some of the statements in this answer to the question asked by B. S.

Code wire is not of the highest quality, as would be believed from this answer, but represents wire that will pass the comparatively easy tests required by the Fire Underwriters.

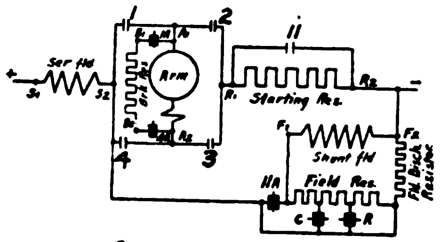
What, in the question and its answer, is referred to as "30 per cent rubber compound grade" would be better designated as 30 per cent Para or Hevea rubber. The rubber compound containing that proportion of the grade of rubber specified is, when properly made, the highest type of rubber insulation.

The intermediate type generally contains about 25 per cent of Para or Hevea rubber and has insulating qualities lying between the other two types of rubber insulation.

If you leave the wiring of your plant to a contractor and do not specify what kind of rubber insulation he must have on the wire, you will get Code wire for it is the cheapest that will pass the Underwriters' requirements. If you want the best type of insulation, either because you cannot afford to have shutdowns on account of breakdowns of the wire, or if you have unusually difficult conditions to meet, due to dampness or special manufacturing processes, use the 30 per cent Hevea or Para compound. If you want something better than the Code wire, but do not think that you need the very best insulation, or if you cannot afford to pay the price asked for it, use the intermediate grade of insulation.

I do not mean to insinuate that the code wire is not good. It is good, but the intermediate grade is better, and the 30 per cent Para is best.
Westfield, N. J. G. H. MCKELWAY.

Changing Control to Obtain Lower Motor Speed.—The motor on our reversing planer drive is a 10-hp., Westinghouse, frame 90, type SK, shunt-wound motor having a speed range of 250 to 1,000 r.p.m. We have no spare for this motor and when it fails, it is necessary to substitute a 15-hp., 400/1,600-r.p.m., type SK Westinghouse, shunt-wound motor. The automatic control on the planer drive is arranged as shown in the accompanying diagram. The sequence of operation of the contactors is shown in the table. In this tabulation the number of the contactor is given in the left-hand column, the "Cut" column refers to the cut stroke, the "Return" column refers to the return stroke, and the "Bk." column refers to the dynamic braking applied between reversals. The control is arranged so that a low speed is used on the cutting stroke and a high speed on the return stroke. These speeds are obtained by proper adjustment of the shunt-field rheostat. When using the 400/1,600-r.p.m., 15-hp. motor, the speed of the return stroke can be properly adjusted, but the cutting stroke is too fast. Full field on the motor gives 400 r.p.m., whereas a speed of approximately 300



Sequence of Contactors

Con	Cut		Bk.	Off.	Bk.	Return	
1						O	O
2	O	O					
3						O	O
4	O	O					
11	O						O
1A	O	O	O	O	O		
4A			O	O	O	O	O
11A		O	O	O	O	O	

r.p.m. is desired. Can readers tell me any way that I can obtain this speed on the 15-hp. motor without rewinding it or changing its fields? Is it possible to obtain satisfactory results with resistance in series or in parallel with the armature? If so, how much resistance should be used, or how should I go about determining the correct amount?
Indiana Harbor, Ind. A. R. D.

In answer to the question asked by A. R. D. the speed of a d.c. shunt motor may be reduced by decreasing the voltage impressed on the armature. The three limitations of speed control, when using resistance in series with the armature, are: (1) Widely varying speeds with changing loads. (2) Inability to reduce the speed with light loads. (3) Inability to secure stable low speeds.

It is impossible to state just how much resistance should be put in series with the armature in order to obtain a definite motor speed unless the amount of motor current is definitely known.

For illustration we can consider a 10-hp., 230-volt, d.c. shunt motor, drawing 36 amp. from the line, requiring a constant torque during the cutting stroke on a planer. If the control wiring is arranged as shown in Fig. 1, so that the resistance is in series with the armature on the cutting stroke, the voltage applied to the armature will be reduced by an amount equal to the voltage drop across the resistor. This drop in voltage is equal to the resistance of the resistor times the current flowing through it or $36 \times 1.5 = 54$ volts. The voltage at the armature terminals is 230 — 54, or 176 volts. The

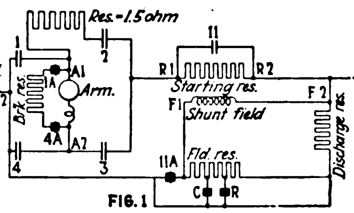


Fig. 1—Reducing the speed of a d.c. shunt-wound motor by inserting resistance in series with the armature.

speed will decrease in direct proportion to this applied voltage. The speed is then equal to $(176 \div 230) \times 400 = 306$ r.p.m. If the armature current is only 25 amp., then the voltage drop is 25×1.5 or 37 volts approximately. The voltage at the armature terminals is 230 — 37, or 193 volts. The motor speed now equals $(193 \div 230) \times 400$ or 335 r.p.m.

In the second case, an armature shunt could be used across the armature as shown in Fig. 2, but this procedure is not recommended by the writer for continuous duty as the current losses in the resistors would be prohibitive. If the shunt resistance method is used, it would be necessary to put a back contact on No. 3 switch and change the brake resistance, because as the shunt resistance is in parallel with it while on the braking point, the resistance path around the armature would be decreased and thus cause a stop which would be much quicker than ordinary. It is not very safe to have this braking current more than 300 per cent of the full-load current. By using the armature shunt, it is possible to reduce the motor speed at all loads, and with light loads a considerable speed reduction results. When the armature shunt is used, it is necessary to put a series resistor between R1 and No. 2 reverse switch, which resistor will be "in" on the cutting stroke.

The speed of the motor, when it is connected as shown in Fig. 2, can be calculated as follows: Armature current $= I = 36$ amp.; armature volts $= E_a = 176$ volts; current through shunt $= E_a \div 17.6 = 10$ amp. The drop across the series resistor $= 1.17\,(I + (E_a \div 17.6)) = 54$ volts. Now, $E_a = 230 - 54 = 176$ volts. Current through the series resistor equals $36 + 10 = 46$ amp. Then, speed equals $(176 \div 230) \times 400 = 306$ r.p.m.

If A. R. D. desires more information concerning resistance shunts, I would recommend a book entitled "Principles of Electric Motors and Control" by

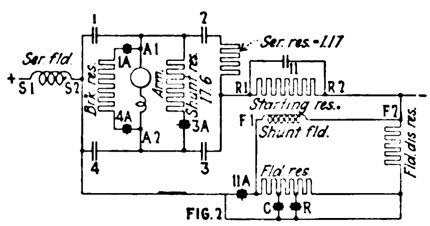


Fig. 2—In this instance the speed of a d.c. shunt-wound motor is reduced by connecting resistance across the armature.

Gordon Fox, published by the McGraw-Hill Book Co.

Foreman, Electric Dept., E. E. STEAD.
Carnegie Steel Co.,
Mingo Junction, Ohio.

* * * *

What Causes Heating of This Cable Box?—There are six 1,000,000-circ. mil cables connected in parallel per phase on the cable run between our 2,000-kw. 3,000-amp., 480-volt turbo-generator and the oil switch. These cables are grouped in six conduits, each of which holds one cable from each phase, or a total of three cables. The conduits terminate in the bottom of a sheet-iron distribution box. In this box the cables are regrouped so that all of the cables from one phase go out of the left-hand side of the top of the box; all the cables for another phase go out through the center of the top of the box; and the six cables for the remaining phase go out through the right-hand side of the top of the box. With this arrangement the entire top half of the sheet-iron distribution box heats up. What causes this heating and how may it be overcome? Should I make the box of fiber instead of sheet iron?
Bellingham, Wash. E. M. D.

In answer to E. M. D.'s problem, the heating is caused by induction. The cables for any circuit, when run in conduit or where a magnetic ring may be formed, should be run as close together as possible. When each phase wire or cable is run in a separate conduit or out of a metal box at any distance apart from the other wires, both the conduit box and the cable will heat. Replacing the metal box with one made of fiber will eliminate the heating of the box, but will not eliminate the heating of the cables. The carrying capacity of the cables is reduced by running them in the manner that E. M. D. has employed.

Electrical Engineer, H. E. STAFFORD.
Provincial Paper Mills, Ltd.,
Port Arthur, Ont., Can.

* * * *

If E.M.D. had taken his cables out of the box grouped in the same manner as they entered the box, there would have been no heating because cables from each phase would have passed through the same hole. This heating is not serious on cables or wires carrying a small current, but when larger currents flow this heating effect is more pronounced. The heating is caused by eddy currents induced in the top of the metal box. E.M.D. has no doubt observed that practically all alternating-current magnets are wound on spools, made of either brass or steel, and that the spool has a small slit through its entire length. The object of this slit is to prevent the flow of eddy currents through the metal.

The heating encountered by E.M.D. may be eliminated by sawing a slit from each hole to the adjacent one in the top of the box. This would be the same as regrouping the cables, so that the effect would be the same as though all the cables were carried through the same hole. It probably would not be necessary to saw the slits so that they connected one hole to the other, for a slit cut a short distance on each side of the hole would break up the path for the eddy currents to such an extent that they would be dissipated by the resistance of the additional metal through which the eddy currents would have to flow in order to complete their path.

As the wires are already installed

and in operation, the obvious thing to do would be to saw a slit from the front end of the box towards each hole in the top of the box. This would put a slit clear through one side of the top of the box, which would, of course, open any short-circuited path around the conductors as they pass through the top of the box.

If this work is done while the current is on, some provision should be made to catch the iron dust from the saw as it might cause the switches or other devices to arc across, probably doing damage or injuring someone.

Birmingham, Ala. GRADY H. EMERSON.

* * * *

In a recent issue of INDUSTRIAL ENGINEER, E.M.D. asks what causes heating of a cable box. There is little doubt that this is from eddy currents in the iron of the box between the conductors leaving the box. Temporary relief can be obtained by cutting away the iron between the openings through which the cables pass.

With heavy alternating currents, iron boxes frequently heat. Good practice in this case is to substitute copper or brass in the construction of the box. Transite or asbestos lumber may be substituted where there is no moisture.

Osborn, Ohio. T. H. ARNOLD.

* * * *

Charging Storage Batteries — Will some reader of these columns please inform me how, if possible, I can make up a unit to charge small storage batteries from a 220-volt, direct-current power supply? The storage batteries range from 1 cell (2 volts) to 6 cells (12 volts) in potential and up to 240 amp.-hr. in capacity. Can I charge these batteries from a lamp bank? If so, how many and what size of lamps should I use, and how should they be connected? Any other information that readers can give me along this line will be greatly appreciated.

Chicago, Ill. W. A. B.

The type of charging set for W.A.B. to install will depend on the amount of charging that he has to do. If considerable charging is to be done, a motor-generator set will result in the lowest annual net cost, but in the event that batteries are to be charged only occasionally, the lamp bank type of charging will prove to be the most profitable investment.

When 220-volt lamps are used, the current required by a 32-cp. carbon lamp is 0.5 amp. and a 100-watt lamp requires 0.4 amp. For battery charging work, a 32-cp. carbon lamp is preferable to many types of lamps which are more efficient.

The charging rate of small batteries is about 2 amp. and the rate for the larger ones is 12 amp. After knowing the maximum number of amperes that will be demanded from the lamp bank, enough lamps should be connected in parallel to furnish the required number of amperes during the initial charging period. The current supplied to the batteries can be regulated, when necessary, by cutting some of the lamps out of the circuit.

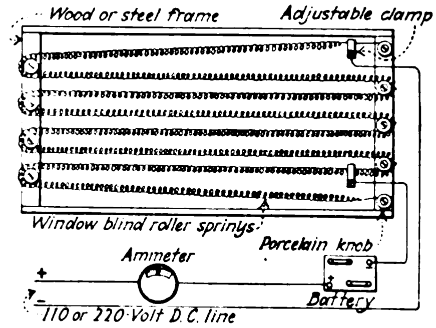
There is a type of battery charging set on the market, which limits the amount of current supplied to the battery by inserting a carbon compression disk resistance in the line that supplies current to the battery. The amount of current supplied to the charging circuit is regulated by turning a screw that compresses the carbon disks. It has a range of 1 to 30 amp. and is mounted on a stand with a switch ammeter and protecting fuses.

This device for the charging of batteries is inexpensive, besides embodying the advantages of being compact, easily controlled, and quickly adjusted.

Chief City Electrician, H. J. ACHEE.
Woodward, Okla.

* * * *

In answer to W.A.B's. question, I wish to submit my ideas on charging storage batteries from direct current power lines. Where central station power must be used, the battery can be charged cheaper in a regular battery service station, due to the power lost in the resistance bank, necessary to limit the current and voltage to the rating of the battery, when charging from high-voltage lines.



Roller curtain springs arranged to limit the flow of current in a battery charging circuit.

As the resistance is in series with the battery, the battery current must flow through it. Considering a 6-volt battery on charge at a 10 amp. rate from a 220-volt line, the voltage across the battery will be 7½ or 8 volts. The voltage drop across the resistance will be, 220—8=212 volts. Ten amperes flowing in the resistance results in a watts loss of $10\times212=2{,}120$ watts, while the battery will require only $8\times10=80$ watts.

A 100-amp.-hr. battery fully discharged would have to be charged for at least 12 hr. to charge it, with a loss of $2{,}120\times12=25{,}440$ watthours or 25.2 kw.-hr. in the resistance. Power as low as 4 cents per kw.-hr. runs the wasted energy cost alone to a figure above $1.00, while a service station will charge a battery in 8 hours for 50 or 75 cents.

Where plant-generated energy is available in large quantities, the following method may be used to good advantage on all sizes of batteries. The resistance consists of a number of roller springs connected together by twisting their ends and mounted on solid porcelain knobs on a wood or steel frame.

The connections and adjustments for proper resistance values are made with adjustable clamps connected to flexible leads from the line and battery, as shown in the accompanying illustration.

The frame should be mounted in a horizontal position so the heat from the springs will go upward without going over the balance of the coils, as would be the case if the frame were mounted in a vertical position as in the figure. The springs should be stretched so that turns are at the very least 3/16 in. apart.

I have found that 8 springs in series will give a wide range of control and will pass 10 amp. from a 220-volt power supply. The springs will lose their temper and stretch if subjected to much over 10 amp. unless very good ventilation is provided.

Chicago, Ill. CARL G. HOWARD.

* * * *

W.A.B. can make up a unit for charging storage batteries by using a lamp bank, or the equivalent of a lamp bank with resistance tubes mounted in standard lamp sockets. It would be much better, however, if W.A.B. were to install a motor-generator set for this purpose because it would be much more economical, as the following calculations show:

A 240 amp.-hr. capacity cell has a normal 8-hr. discharge rate of 30 amp., and should be charged at the rate of 30 amp. for about 10 hr. With a lamp-bank charging outfit the current drawn from the 220-volt line would be 30 amp. Therefore, the energy consumed in charging one to six cells would be 220x30x10=66,000 watt-hr. or 66 kw.-hr. At an assumed cost of 7 cents per kw.-hr. the cost of the charge would be $4.62.

If a motor-generator set is used, the generator should have a maximum voltage rating of 16 volts; hence at 30 amp. output its capacity would be 16x30=480 watts of approximately 0.5 kw. A 1-hp. motor, drawing about 5 amp. at 220 volts, would be large enough to drive the generator. It follows from this that the cost of charging with such a set would be 5x220x10x0.07=$0.77.

If it is assumed that batteries are to be charged on a commercial basis, 10 hours per day for 300 days per year, and if we set down $10 and $100 per year as representing reasonable values of fixed charges for the lamp bank and motor-generator equipments, respectively, we find that the cost of charging as assumed is as follows:

For the lamp bank equipment:

Cost of power, 300×4.62	=$1,386 per yr.
Fixed charges	= 10 per yr.
Total	=$1,396 per yr.

For the motor generator equipment:

Cost of power, 300×0.77	= $231 per yr.
Fixed charges	= 100 per yr.
Total	= $331 per yr.

Saving in favor of the m.-g. set = $1,065.00 per year.

This result would have to be modified if the assumptions made do not fit the case under consideration. For a lesser amount of charging per year the saving would be less, while for a larger amount the saving would increase. But if the charging is to be done on a commercial scale, it is safe to say that the motor-generator set is more economical.

The lamp bank equipment can be made up of 60 to 70 100-watt, 110-volt lamps, connected in groups of two in series, in

series with the battery. Each group of two lamps can be separately connected to the circuit by means of a small, single-pole switch. This would give a current range from about 1 to 35 amp. All the parts for this equipment can be bought at any electric supply store.

Resistance tubes mounted in standard Edison lamp sockets can be bought through dealers or directly from the Ward Leonard Co. About 30 to 35 tubes rated at 250 ohms, 200 watts, 220 volts, 0.89 amperes each would be suitable for this purpose, and they are cheaper than the lamps mentioned above.

The motor-generator equipment should consist of a 1-hp., 220-volt shunt motor with starter; a 0.5-kw., 16-volt generator which should be arranged for separate excitation from the 220-volt line; a field rheostat; a series rheostat of about ¼-ohm total resistance, 30-amp. capacity; a d.c. reverse-current relay; and two fused line switches, one for the 220-volt line and the other for the 16-volt line.

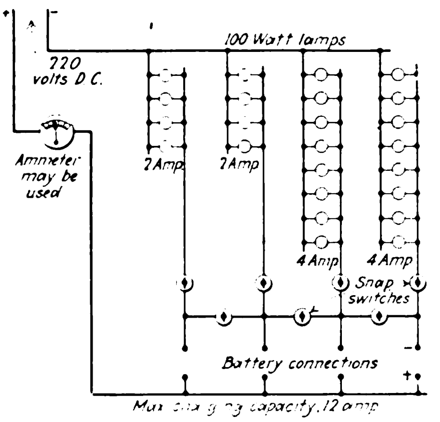
The series rheostat is to go between the generator and the battery and should have at least six steps for adjusting the voltage of the charging circuit. The reverse current relay protects the battery and the generator in case the 220-volt power fails. The motor-generator equipment can be bought from manufacturers agents in Chicago. For addresses see the E.M.F. Year Book, or consult your electrical dealer.

Newark, N. J. H. H. METZENHEIM.

* * * *

W.A.B. can charge storage batteries from a 220-volt d.c. circuit by using a lamp bank to regulate the flow of current to the batteries.

The accompanying wiring diagram shows how a series-parallel arrangement of the lamp in a lamp bank can be adjusted so as to furnish the desired amount of current. Should the starting current be more or less than the desired amount, the proper number of receptacles can be cut in or out of the circuit as required. The fact that a 100-watt lamp allows approximately 0.5 amp. to pass through it, when connected to a 220-volt line, determines the number of lamps that will be needed, which in this case is 20.



Battery charging set designed for use with a 220-volt d.c. service line.

In place of using lamps, the Ward Leonard enameled EB type of resistors can be used. These resistors are designed for a standard lamp base, and the number of sockets needed will depend on the capacity of the resistances employed. When ordering the resistances, you should specify whether they are to be used on a 110- or 220-volt line.

The average charging rate for batteries, when the current is first switched on, is about 10 amp. After the batteries begin to gas, the charging current should be reduced to approximately 5 amp.

When the specific gravity of the liquid in the battery indicates that the battery is fully charged, the supply current is reduced to 2 amp. and this rate of charging is continued for a period of an hour or so. Hydrometers, which are suitable for testing the specific gravity of the liquid in batteries, can be purchased from automobile accessory dealers.

These hydrometers should be so marked that a man who is inexperienced in the charging of batteries, can easily tell when a battery is or is not fully charged.

A storage battery is considered fully charged, when the specific gravity reading is between 1.27 and 1.29. A voltmeter reading, by the way, does not indicate the amount of current available in a battery, unless a reading is taken when the battery is delivering current at its rated capacity.

If you so desired, the switches that are indicated in the sketch can be eliminated; in this case the flow of current can be regulated by screwing the lamps into or out of their respective receptacles.

In order to determine a positive wire from a negative one, two methods are generally employed. The polarity indicator offers the simplest and most convenient method of picking out the positive wire. The other method takes advantage of the fact that, while a small current is flowing, numerous bubbles will rise from the negative terminal of two wires, when they are immersed in a solution of salt and water. A simple way of limiting the flow of current through these wires is to connect a lamp in series with one wire.

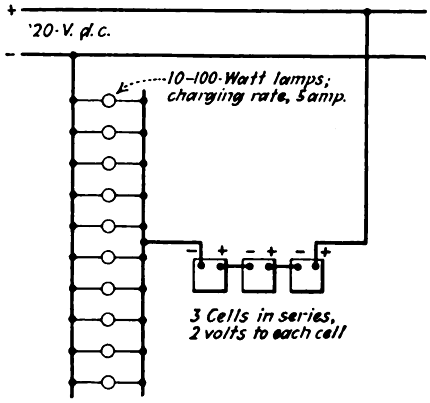
During the charging period, all danger of a fire or an explosion can be avoided by keeping open lights away from the batteries while they are gassing.

Birmingham, Ala. G. H. EMERSON.

* * * *

Before proceeding with an explanation to W.A.B's. question, I would suggest that the reader look at the accompanying sketch. Batteries are often charged from a 110- or 220-volt d.c. current supply, by using a lamp bank to regulate the flow of current. From the sketch, it is evident that by adding more lamps to the parallel circuit, more current can be supplied to the battery, and the current supply can be diminished by unscrewing the necessary number of lamps from their receptacles.

The voltage of the lamps should be the same as the voltage of the supply circuit. Although 100- or 150-watt lamps are often used, carbon lamps are



Lamp bank employed to regulate battery charging current.

to be recommended for this work. If a 100-amp.-hr. battery is to be charged use ten 100-watt lamps or seven 150-watt lamps. This arrangement will give a charging rate of 5 amp. When the batteries are nearly charged, the flow of the current can be reduced the necessary amount by unscrewing some of the lamps from their sockets.

In connecting the batteries to the charging wires, only those cells which have the same capacity should be connected in series.

Middlesboro, Ky. C. L. UMBERGER.

* * * *

In reply to W.A.B's. question, I would say that a lamp bank consisting of 32-cp. lamps will make a very substantial unit for regulating the flow of current between a 220-volt d.c. line and battery charging terminals. When the line current is 220 volts, 110-volt lamps can be used by connecting them in series-multiple. When 220-volt lamps are used, all the lamps are connected in parallel. One 32-cp. 110-volt lamp will give 1 amp., while one 32-cp., 220-volt lamp will give ½ amp. Therefore, a multiple of these lamps will give the charging rate required.

As to the number of lamps to be used in charging, of course, one must not exceed the charging rate. Therefore, it would remain for W.A.B. to decide the charging current most suitable for the battery on charge. There are two methods of charging: one is to apply the full rated charging current to the batteries until they are nearly charged. Then the current rate is reduced to one-half to finish off that charge. The other method is to apply one-half or less of the charging rate to the batteries; this will lengthen the charging period, but seems to be easier on the battery than the higher charging rate.

As to connecting the batteries, it is only a matter of connecting the different batteries, positive to negative. As to the ampere-hour capacity of the batteries, the charging period should be recorded at start and finish; then multiplying the charging rate in amperes by the number of hours the battery was on charge, will give the ampere-hours put in the battery. Personally I use the specific gravity and voltage for guidance in charging batteries. Most automobile or other small batteries usually

have the electrolyte of 1.280 to 1.300 specific gravity, with a voltage of 2.6 volts per cell when the cells are fully charged.

Maintenance Inspector, E. J. EVISH.
Kaministiquia Power Co.,
Fort William, Ont., Can.

* * * *

Method of Connecting Generator to Bus.—In the power house of our lumber mills we are planning on installing a 6,000-kw. three-phase, 480-volt, 9,000-amp. turbo-generator. To the bus there are now connected an 800-kw. and a 2,000-kw., 480-volt generator. I would like to know what readers would recommend for connecting the 6,000-kw. generator to the bus. Should cable be used, and if so, how should it be arranged so as to eliminate the inductive effect and its consequent heating due to the heavy current flowing? Would it be better to use busbars and if so, how should they be supported and arranged so as to reduce the induction? Any recommendation that readers can give for the layout of the connection between the generator and bus will be appreciated.
Bellingham, Wash. E. M. D.

Referring to E. M. D.'s inquiry, it would seem that for a machine of this size such a saving in copper and control apparatus could have been made by changing to 2,300 volts as to justify some changes in the driven equipment about the plant.

If the run from the new generator to the switch and bus is not too long and crooked, busbar copper may be used to advantage. A current density of at least 1,000 amp. per sq.in. could be used in which case a 9,000-amp. current would require 9 sq.in. or three ½-in. by 6-in. busbars. These bars could be carried in the usual way without any danger of induction or heating of the busbars.

Should it be necessary to use cable, nine 2,000,000-circ.mil cables will be required per phase. These cables can be fanned out from the machine terminals and secured to the ceiling or wall, the main precaution being to keep all the cables of one phase together so as to avoid induction troubles.

We have a similar installation, although both of our generating units are smaller than the one E. M. D. has reference to, and our units require only two cables per phase instead of nine. Standard, porcelain-bushed cable racks are used and have never shown any indications of heating or trouble.

If, however, it is necessary to run these cables in iron conduit, the same number of cables must be used for each phase. In each conduit must be grouped one A, one B, and one C cable or a multiple of this combination, and all cables should be brought to a common terminal at the far end from the generator. Also, all the conduits should be solidly connected together with heavy ground clamps at both ends of the cables.

Plant Engineer, H. D. FISHER.
New Haven Pulp & Board Co.
New Haven, Conn.

* * * *

In answer to the above question by E. M. D., my advice would be to approach the problem with caution and get the best advice available. The writer assisted in the solution of this problem on one occasion and has used a different solution on subsequent problems in order to secure a proper layout of the connections.

The installed cost of the electrical equipment for a unit of this current rating is excessive in proportion to the kilowatt capacity, the switching equipment is cumbersome and of special design, deliveries are slow, and some equipment is none too satisfactory in operation. The unexpected difficulties from induction may form a very appreciable addition to the expense and trouble incident to getting the new unit into operation.

In 1916-17 one of the copper mining companies installed a 6,000-kw., 480-volt, three-phase, 60-cycle, turbo-generator as an addition to a plant having one 2,000-kw. turbo-generator and three 1,250-kw., engine-driven units.

Preliminary designs and cost estimates were made for both copper bar and cable connections from the generator to the switching equipment. The cable arrangement gave the best installation in this case. Eight 2,000,000-circ.mil, v.c., single-conductor cables per phase were used.

This arrangement required 24 runs of 80 ft., totaling 1920 ft. of cable. To avoid induction drop the cables were made up in sets of three, one set for each phase, and each set was given a complete twist in 9 ft. The result resembled an overgrown telephone cable. Large brass castings placed on 3-ft. centers maintained the cables in position and supported the weight. Micanite bushings protected the insulation where the cables passed through the supporting castings. The inductive drop was negligible and the finished appearance was neat and workmanlike in every particular.

Two, three-pole, 5,000-amp., electrically-operated carbon circuit breakers were connected in parallel for the main switch. These were arranged to be operated either singly or together from the switchboard. In synchronizing one breaker was used, the second breaker being closed after the machine was paralleled.

The bus leaving the switches was divided into six parallel sets of bars. A number of additional feeders were added at this time, and the total new copper to reinforce the existing bus system was approximately 19 tons of ½-in. by 5-in., hard-rolled copper bar.

A short-circuit, which developed on the bus shortly after the new bus was placed in commission, demonstrated the wisdom of wide spacing of the bus and secure anchorage of the bars. An 8-in. to 10-in. clearance should be maintained between uninsulated conducting parts, or suitable barriers should be installed.

The copper should be figured very conservatively; the current density should not exceed 500 amp. per sq.in. Where more than five ½-in. by 5-in. bars are required, the bus should be split into two or more parallel runs. Great care should be exercised in the make-up of all joints and taps in the bars to prevent them from becoming overheated and causing trouble.

All iron should be eliminated so far as possible from the bus structure and adjacent parts. Brass or bronze should be used for bolts, washers, bus clamps, bus supports and framework. In the above installation, extra-heavy, 1½-in. brass pipe was used for the supporting frame. Even with this precaution, trouble developed from induced currents circulating in the framework and heating the pipe. Many of the joints had to be insulated before this trouble was remedied. Building steel and reinforcing in the concrete were affected. The expense incident to remedying these unexpected troubles was quite large and became quite serious before the remedy was satisfactorily worked out and applied.

The final effect was an entirely satisfactory solution of the problem in that the engineering difficulties were overcome. From the economic aspect, however, the cost of wiring, control, and metering equipment formed an undue percentage of the total installation cost.

As the problem is given, there appears to be a very considerable increase in generating equipment which presupposes an increase in motor equipment. Probably the most satisfactory arrangement would be the installation of a higher voltage distribution system with stepdown transformers, and transformer connections to the existing system.

Osborn, Ohio. T. H. ARNOLD.

* * * *

Trouble with Storage Battery Charging Generator—We are having considerable trouble due to the reversal of polarity on a 50-kw., 120-volt, interpole generator which is used to charge storage batteries on vehicles. The machines were tested for grounds by means of a Megger and a heavy leakage to ground through the acid-soaked benches in the battery charging department was discovered. Having remedied this, the generator was started and immediately the voltmeter read backwards with no load on the machine. We checked the leads from the machine, but they were of such size and so taped together that it would be impossible to reverse them by mistake. We tried to re-excite the field, but could not; so the leads were reconnected so as to reverse them at the generator and not disturb anything at the switchboard. The generator worked satisfactorily for about three days, when the polarity again reversed itself. We reversed the generator leads to their original position and since then the machine has been operating satisfactorily. I do not know what caused this reversal of polarity and should like to have readers give me their suggestions.
Sacramento, Calif. J. T.

It seems likely that the generator which J. T. is puzzled over, has received enough return voltage to change the polarity of the field.

This could also be caused by other apparatus in the line that would discharge through the field in the event that the circuit from the generator was broken.

There is no reason for not being able to re-excite the fields, as only enough voltage is needed to overcome the residual magnetism.

The re-exciting of the fields can be accomplished by applying current from an outside source to the field (shunt) coils, or by insulating the brushes from the commutator and then closing the main switch.

I would advise J. T. to look around for poor connections, or to consider the possibility of the batteries discharging through the generator.

Chief Electrician, E. J. MORRISSEY.
Western United Gas & Elec. Co.,
Aurora, Ill.

Electrical Service

around the works

For this section short articles describing ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing, and emergency or special installations.

Method of Cleaning Stranded Wire Before Applying Solder

STRANDED wire may be very easily cleaned in preparation for soldering, if one will first strip off the bulk of the rubber insulation and then rub the exposed wire strands lengthwise with a piece of file card.

The short stiff wire bristles of the card will dig down between the rounds of the strands, cleaning and at the same time slightly roughening the surface of the wire.

To one who has wasted time and temper, trying to clean between the strands of wire with the point of a knife, this method will be found to be a big improvement over the customary procedure.

Providence, R. I. JAMES P. MARSHALL.

Placing Ground Wire in Conduit Insures Protection

IF THERE is any wire in an installation which needs mechanical protection, it is the ground wire. When other wires become broken or disconnected through mechanical injury, the fact immediately becomes evident through the failure of the equipment depending upon the wire, but if the ground wire becomes inoperative, the fact is generally not disclosed until too late. Furthermore, ground wires, because of the location in which they are placed, and especially in the vicinity of the water pipe connection, are particularly subject to mechanical injury.

The National Electrical Code, section 905 D, requires that all ground wires shall be protected from mechanical injury. About the only feasible way to protect the ground wire adequately is to put it in conduit, not part of the way, but all of the way, and unless it is made up to the water pipe with conduit types of ground fittings the conduit should terminate in an iron or wooden box, enclosing the ground clamp and connection.

The methods of grounding shown in the accompanying diagrams are very satisfactory under the present Code requirements. It will be observed that a common conductor is employed for grounding both the conduit and the service wires. This conductor consists of a copper wire in multiple with the protective conduit. Placing the protective conduit in multiple with the copper wire decreases the resistance of the circuit to about one-third of its previous value and about doubles the carrying capacity. There are many other obvious advantages.

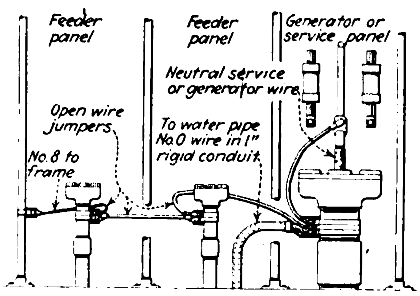


Fig. 1—This method of making a connection to the ground wire is particularly adaptable around a generator or service panel.

The National Electrical Code, Section 905E, reads as follows:

"Where a secondary system is grounded at the service, the equipment, conduit, armored cable, metal raceway and the like may, with the permission of the inspection department, be connected to the circuit grounding conductor, but otherwise shall have a separate grounding conductor of their own."

When the local inspection department objects to the use of a common conductor, the method shown may very readily be modified to provide for two independent conductors.

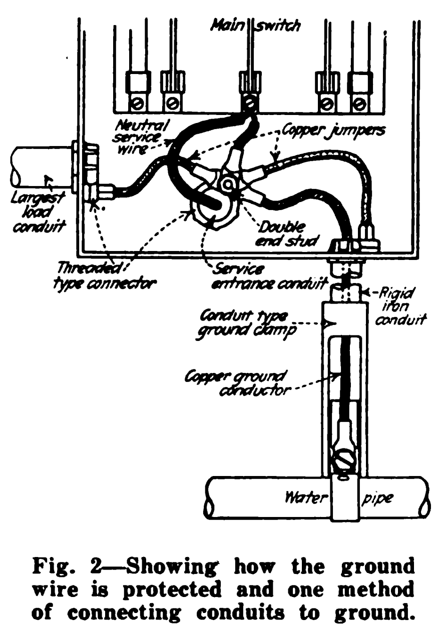


Fig. 2—Showing how the ground wire is protected and one method of connecting conduits to ground.

The bushings used on the end of the conduits are made of galvanized malleable iron. These bushings are designed to accommodate a bronze soldering lug which makes a direct contact with the conduit and at the same time locks the bushing in place.

When two independent conductors are used the question is sometimes raised at to whether or not the Code permits the protective conduit to be used as the grounding conductor for the service entrance conduit. Such use of the protective conduit has been specially approved by the Underwriters' Laboratories.

Manager, Groundulet Co. Newark, N. J. S. W. BORDEN.

Testing Insulation Resistance of Electrical Equipment

DIRECT-READING, insulation-resistance-measuring devices have many uses around an industrial plant. For example, they will show at a glance the condition of the insulation in light or power wiring, either at the time of construction or after the plant is in operation. The ordinary magneto will show short-circuits and direct grounds, but it does not show swinging or high-resistance grounds and, therefore, is not an entirely reliable instrument.

In testing motors, a device that will measure the insulation resistance is a practical necessity. Very often, while a motor is at rest a ground cannot be found by the ordinary magneto or bank of lamps, for the reason that the coils assume their natural positions, while when running the internal stresses due to magnetic induction and centrifugal force will distort the coils and chafe the insulation, causing a so-called swinging ground. The writer has come across several cases of this kind which have been readily found with a Megger.

It has been the practice of the repair department in the plant with which the writer is connected, to test all coils as they are inserted in a motor during a rewinding job. This test shows the condition of the insulation not only between the coils and the core, but also between the layers of various coils.

In locating faults in compensators and controllers, the insulation-resistance method is the only means of locating a high-resistance path through mica, wood or fiber. Where water or metallic dust has caused a path between contacts, a carbon path of high resistance is usually formed in the insulation. It is difficult to locate this path by the ordinary magneto or lamp bank, but with a suitable megohmmeter the resistance can easily be measured.

According to the Standardization Rules of the A.I.E.E., the insulation

resistance of a machine at its operating temperature shall be not less than that given by the formula:

Insulation resistance in megohms = voltage of terminals ÷ (rating in kva. + 1,000)

This rule should be adhered to as it is really low, and might be also considered arbitrary, especially on machines of high rating. For the sake of comparison, the accompanying table shows the safe limit as required by the above rule, and what I consider the safe limit from my experience with all types of equipment over a considerable number of years.

Although the A.I.E.E. formula may give an insulation resistance that will be ample under various conditions, from my point of view I feel that it is not infallible. For instance, when it is applied to a 75-hp. and a 200-kva. motor, both operating at 550 volts, the results are 520,833 ohms in the first case and 458,333 ohms in the latter.

In practice, I do not consider it safe to attempt to place in service a motor that shows a reading below 750,000 ohms when the impressed voltage is 550 volts.

Not long ago, at our plant, a motor gave out and two coils had to be replaced. In order to do this, the top sides of ten coils had to be lifted and replaced. The windings were then dipped and baked for 48 hr. While still hot, a Megger test was taken and a reading of 600,000 ohms was recorded. Although this reading was not so high as expected, the motor was put back in service and lasted three weeks, when two coils in each of two phases broke down to ground. The motor was in a perfectly dry location and operated 20 hr. per day in two shifts of 10 hr. each.

In winding motors with a complete set of new coils, I try to get a reading of at least 10 megohms, cold test, for motors with open slots and from 100 megohms to infinity, cold test, for motors with partially-closed slots.

In testing power wiring in conduit at our plant, nothing short of infinity on a 100 megohm Megger is accepted, with the wires disconnected at both ends, and four megohms when connected through service switches, compensators and motors. This is, of course, for a new installation operating at 550 volts.

Compensators and a.c. controllers must show on test not less than 500,000 ohms; otherwise they are overhauled and re-insulated. The same, or a higher, reading is required on all d.c. control apparatus, for both 220 and 550 volts. Commutators, armatures and field coils are not considered in good condition when they give a reading of less than 750,000 ohms.

Following are the results of some tests made recently:

Test No. 1—75-hp. motor, 1,800 r.p.m., three phase, 550 volts, direct-connected to a centrifugal pump. Reading when installed, 50 megohms: reading after two years' operation in a damp place, hot 9 megohms, cold 10 megohms.

Test No. 2—35-hp. motor, 1,200 r.p.m., three phase, 550 volts, rewound. Cold test of each phase, open: to ground, 8 megohms. Cold test when star-connected, 10 megohms. This motor had open slots and form-wound coils, varnished but not baked after winding.

Test No. 3—10-hp., 1,800-r.p.m., three-phase, 550-volt motor with partially-closed slots, 55 turns per slot. Test of each coil as inserted, infinity. Test of completed winding after wedges were inserted, infinity. Test, both hot and cold after being dipped and baked, infinity.

Test No. 4—50-hp., 1,200-r.p.m., three-phase, 550-volt motor. This motor had 18 defective coils removed and replaced with new ones. This necessitated lifting 10 extra coil sides which were afterward replaced. After being repaired, the motor was varnished and baked. When taken from the oven and allowed to cool, the Megger gave a reading of four megohms. After standing in the shop for three months, a reading of 800,000 ohms was registered, due to collection of moisture. An ordinary magneto gave no signal.

Safe Values of Insulation Resistance

Machine Rating Volts	Machine Rating Kva.	A.I.E.E. Standard, Megohms	Writer's Standard, Megohms
110	20	0.10784	0.25
220	20	0.21568	0.5
440	50	0.419	0.75
550	100	0.5	1.0
1,100	100	1.0	2.0
2,200	100	2.0	5.0
11,000	500	7.33333	20.0
22,000	1,000	11.0	Infinity

Test No. 5—Four high-speed, 550-volt motors, ranging from 5 to 25 hp. were submerged, due to a blocked sewer. The motors were taken out of service immediately and placed in an electric oven. After being in the oven from 5 p.m. to 8 a.m. the following morning, they were taken out and tested. Three of them gave hot readings of 900,000 ohms, 1 megohm and 1.2 megohms respectively, while the fourth gave a reading of 250,000 ohms. As part of the mill was down, it was necessary to replace the motors as quickly as possible. Three of them were considered O.K., while a chance was taken on the fourth. Three of them stood up while the one showing the low reading went out three days after being put in service. A magneto was also used on this motor and gave no signal.

In locating swinging grounds I have found the insulation-resistance test to be indispensible. This type of ground is caused by chafing of the insulation against the core or slot sides, or by high-resistance carbon paths between conductors. Such grounds can be located by the "smoke method," but this usually does considerable damage.

A high-resistance path between two contacts of an operating bar of a compensator or controller may not be revealed by testing with a lamp bank or a magneto, as the insulation is not sufficiently carbonized, but it will show up when full voltage is applied. Of course, where a fuse is blown and no trouble is found in the motor, a short-circuit is assured, but if a magneto or lamp bank shows no short-circuit, the trouble is mystifying to say the least. I have had several cases of this kind where the needle of the Megger would swing from zero to infinity in successive oscillations, on account of the path being broken and closed by the movement of minute particles of carbon during the passage of the current. This may sound theoretical, but the fact remains that this is what actually happens.

Electrical Engineer, H. E. STAFFORD.
Provincial Paper Mills, Ltd.
Port Arthur, Ont., Can.

Types of Signal Systems Used Around a Cement Plant

INDUSTRIAL signals may generally be divided into two principal classes: audible and visible. The bell and the horn are the main representatives of the former class; the light and the semaphore of the latter.

Every one of these signals has its own particular field, and, if intelligently applied, will make for greater safety and production.

In cement plants, audible signals find a much wider application than visible signals; to anyone familiar with the operation of cement plants the reason is obvious—mill operators and others do not stay in one place all the time, but are often in a position where they would not notice the flash of a light, yet the sound of a horn or a bell would easily attract their attention.

In choosing an audible signal, however, care must be taken in order to have the sound of the signal as different as possible from the noise of the running machinery. Where Kominuters, tube mills, griffin mills or almost any other type of grinding machinery is running, the sound of a bell or gong is very difficult to distinguish, while a horn will be easily heard.

In storage places, in stockhouses and along conveyors, a small clear-toned bell, which is much cheaper than a horn, will generally be quite satisfactory.

Visible signals find their main field of application outside of buildings, around quarries or in places where the attendant or operator has to stay in one place all the time, such as at the mixing scales, packing machines, where gypsum is added to the clinker, where men are tapping cement in stockhouse tunnels, and the like. In all these places the light, which is inexpensive, is quite satisfactory.

In the case of quarries where blasting operations are carried on intermittently and at no particular set time, both visible and audible signals should be used. A warning should be given not only to plant employees but to anyone who might approach the quarry, especially if it is situated near roads where anyone might be traveling while blasting is going on. In such cases, a system of signalling such as outlined below may be used to advantage.

A stone-proof shelter should, of course, be provided where all quarry employees will be safe.

The steam shovel attendant should give the first signal, long enough before the blast, for anyone near the quarry to take shelter. From this shelter, it should be possible to operate all the signals, or to signal to some other employee whose duty it is to operate them.

For the safety of the employees in other departments of the mill, horns should be placed just outside of all doors which are within reach of flying stones, where men might happen to walk out at the time of blasting.

If railroad tracks are near the quarry, such as tracks for bringing in clay, shale, gypsum or coal, or for shipping cement or rock, semaphores should be placed in such positions that the train crews will be sure to notice them and know that blasting is going on.

A large bell operated with a rope, such as is generally used on locomotives, also makes a very effective signal which can be heard for a long distance.

With such a system of signals operated from the shelter, there should be very little chance of accidents from flying stones, provided ample time is given everyone to get safely away before a blast. A push button switch with the circuit normally opened, connected into a 110-volt lighting circuit, gives a safe and reliable means of signaling.

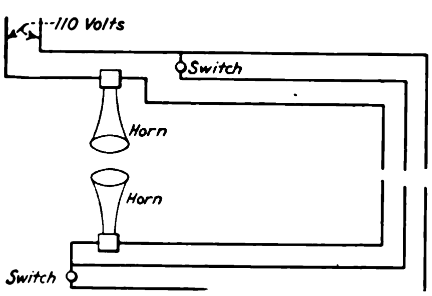
In the case of McCaslin or other kinds of bucket conveyors which dump into a storage and also tap out at the bottom of storage, two horns connected in series, one placed above and one below the storage with a push button switch near each horn, as shown in the accompanying sketch, make a very reliable system of signaling. With the connections shown in the sketch, the attendant either above or below will know something is wrong if his horn does not blow when he presses the button.

No system of signaling, however, will be of much practical use unless certain employees are assigned to do the signaling and are held responsible for it. Every foreman should be absolutely familiar with the system of signaling employed in his department, and he should be held primarily responsible. Also, the foreman should see that all employees under his direction understand the signals used and that nobody but the one assigned to that duty gives the signals. The assigning of one man to give the signals is very important and, in the case of conveyors or other machinery where generally the man starting the motor cannot see that all the machinery thus set in motion is clear, it is absolutely necessary in order that serious accidents be avoided.

Wrong signals or signals that are misunderstood are worse than no signals at all, for men will depend on them and this false sense of security will often lead to serious if not fatal accidents.

Industrial signals should be judiciously and intelligently applied, should be understood by all, and foremen should strictly enforce the use of the signals besides seeing to it that the signals are heeded and obeyed to the letter.

J. H. GALLANT.
Chief Electrician,
Canada Cement Co., Ltd.,
Belleville, Ont., Can.



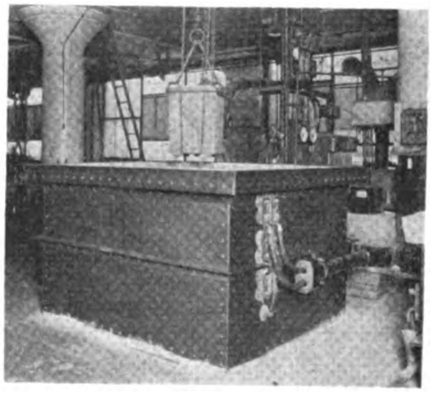
This signal system is so connected that when the horn near the operator fails to work the other horn does not blow.

The operator is thus warned of trouble in the signal system.

Use of Electric Furnace for Annealing Relay Parts

THE relay, upon which the railway signal system depends for its operation, is composed of parts made up of soft Norway iron. After the various machining operations, this iron retains a certain amount of magnetism that can be removed only by careful heat-treatment.

The Union Switch and Signal Co., Swissvale, Pa., manufacturers of railway signaling devices, uses a pit-type electric furnace for this heat-treating process, for the reason that accurate temperature control and uniformity of heating are essential.



This shows the pit type electric furnace being charged with iron relay parts which are to be annealed.

In this Westinghouse electric furnace, the heating chamber is 34 in. by 44 in. and 36 in. deep. The heating elements, of 75 kilowatts rating, are arranged in a double bank on all four sides and on the bottom. The bottom elements are covered by the cast floor plates. The 13-in. wall consists of a firebrick lining and insulating brick. An overhead chain hoist with a short transfer rail is used to handle the furnace cover and the charge, thus greatly facilitating their movement.

The charge is placed in Nichrome pots, and the covers sealed to prevent oxidation during the comparatively long heating process. From one to four of these boxes are placed in the furnace, the cover put on, and the power then applied.

The time required to reach the required temperature is about 5 hr. The work is allowed to soak at this temperature for 1½ to 2½ hr., depending upon the size of the charge.

The charge is allowed to cool in the furnace until the boxes can be handled. This operation usually requires about 20 hr.

A test of one run, in which four boxes containing a charge of 2,880 lb. were heat-treated, showed that 473.5 kw.-hr. were consumed. At 1.4 cents per kw.-hr., the total cost was $6.63 or $0.0023 per lb. of charge. This is a proven consumption of 0.164 kw.-hr., per net pound of charge put into the furnace.

The use of electric heat for this heat-treatment is efficient and economical in that it saves labor and time, eliminates continual watching, and results in an extremely low percentage of rejections under rigid specifications. The operating cycle has been so arranged that the furnace is charged during the morning period.

Before the day is over the charge will have reached the necessary maximum temperature, and will have soaked the proper length of time. The cooling period then starts and is completed some time the next day.

Simple Relay for Lighting Lamp When Telephone Rings

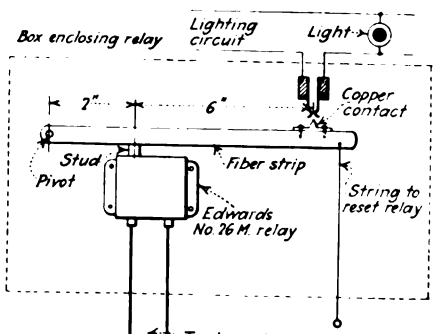
RECENTLY, we installed a telephone in a quarry but, there seldom was anyone near enough to hear the bell. It was, therefore, necessary to provide some sort of signal that would be visible. The accompanying sketch shows how a lamp was made to light whenever the bell rang.

The reset stud on an Edwards No. 26 M. relay was arranged to operate a fiber strip that was pivoted at one end. This stud has a travel of about ¼ in.; so the relay was placed in such a position that the travel of the stud was multiplied to ¾ in. at the copper contact which is attached to the fiber arm, as shown in the accompanying sketch.

Whoever answers the telephone pulls the reset string, breaking the contact to the lamp, and leaving the relay ready for the next call. It is evident from the sketch that there is no danger of the 110-volt circuit becoming grounded or crossed with the wires of the telephone circuit.

This relay has operated very successfully since its installation.

C. A. PETERSON.
Chief Electrician,
U. S. Gypsum Co.,
Alabaster, Mich.



When the telephone bell rings the relay is energized, causing the lever arm to close the 110-volt circuit and light the lamp.

Mechanical maintenance of

Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through the auxiliary transmitting equipment to all driven machines.

Use of Individually-Driven Rolls on Billet Conveyor

WHEN building a conveyor that was designed to carry steel billets from a furnace to a machine which was placed at a 90-deg. angle from the furnace door, a difficult mechanical problem was encountered in driving the eight rolls that were necessary on the conveyor. To convey the billet around the curve each roll had to be placed at a slight angle from the preceding roll. The first roll conveys the billet straight out from the furnace and each succeeding roll was placed at approximately a 12 6/7-deg. angle from the preceding roll. Thus, each roll turns the billet an equal amount until it has made a quarter turn.

If a mechanical group drive had been used, it would have been necessary to have connected a 7½-hp. motor to a mainshaft through a set of spur gears and then install short jackshafts (seven in all) between each set of rolls, with especially-designed bevel or spiral gears driving to each roll and each roll in turn driving the succeeding roll. In addition to the large number of expensive gears, which would have been required, it would also be necessary to use two bearings between each set of rolls for each of the jackshafts.

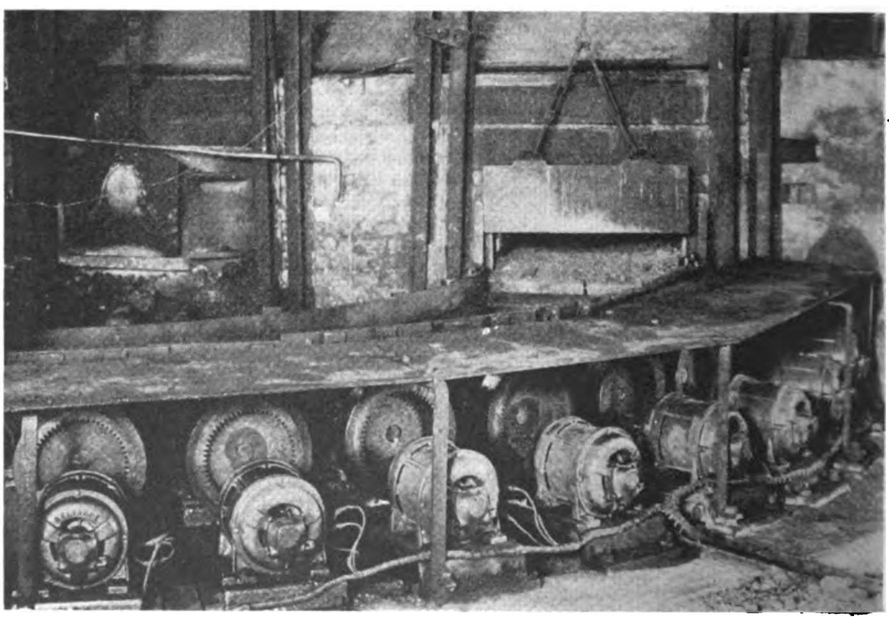
The accompanying illustration shows how the drive was eventually worked out. A 1-hp., 850-r.p.m. Reliance squirrel-cage motor was connected to each of the eight rolls, driving through a pinion and internal spur gear because of space limitations. If a straight spur gear had been used, it would have been necessary either to mount the motor above and drive at the top of the gear, or to lower the motor into the floor and drive at the bottom, if the motor were to be kept on the same line as the roll. Therefore, to make a better appearing and more compact drive than would have been possible if the motor had been mounted at one side, it was deemed advisable to use an internal gear. For protection against dust, covers will eventually be put over these internal gears.

All motors are started and stopped simultaneously from a single starting box. The drive is tied together by an electrical circuit with a single control instead of the complicated mechanical drive first throught of, which would have been more expensive to maintain.

One side of the motor feet was machined parallel to the shaft and a pad on the base plate was finished to fit this machined surface. This made it possible to line up the gears accurately and quickly and use a smaller base than would have been possible if the motor had been mounted to one side. A spare motor was purchased as a protection against a possible breakdown.

J. W. COREY.

Reliance Electric & Engineering Co.,
Cleveland, Ohio.



The eight rolls are driven separately through internal gears by 1-hp. motors.

Comment on "Methods of Reducing Friction Losses"

I HAVE just read the article, entitled "Methods of Reducing Friction Losses" published in the October issue of INDUSTRIAL ENGINEER, and it seems to me that this article exaggerates the inferiority of the so-called plain bearings as compared with the so-called anti-friction bearings.

What I refer to especially is on page 461 where the following sentence occurs: "These bearings require greasing a few times a year at the most, instead of daily or at very frequent intervals, as is the case with plain bearings."

Now as this article confines itself principally to lineshaft bearings I am sure that in 999 case out of 1,000, plain lineshaft bearings today are ring-oiled, and this being the case there is absolutely no necessity for either daily or very frequent oiling of bearings of this construction.

If only people would keep their hands off them they will run lovely for a year at a stretch and as a matter of fact we have had them running in our own shops for 19 mos. without giving them any attention whatsoever and without experiencing the slightest trouble. The Jones & Laughlin Steel Co. states in one of its catalogs that it had a whole installation of ring-oiled bearings in a machine shop running from July 1893 to August 1896 without ever giving them the slightest attention whatsoever and upon inspection at the latter date they were found to be in perfect condition.

So please don't hit the good, old plain bearings too hard, because if only given half a show they are exceedingly good and efficient.

H. F. GADE.

Vice-President,
Standard Pressed Steel Co.,
Jenkintown, Pa.

NOTE: The comments and experiences of other readers on this subject will be welcome.—EDITORS.

Eliminating Trouble from Static on Belt-Driven Machines

STATIC from belt drives, particularly if the belt passes near the hair of women employees, or if it is generated in rooms filled with explosive or inflammable vapors, must be removed or prevented. Friction, high speed, dry belts, and dry air, and so on, are all

contributary causes of static electricity. Friction, however, is the principal cause and therefore the first step in preventing static electricity is to eliminate belt slip. Two of the main causes of slippage are belts which are too loose or too small for the service they are giving. Where poor adhesion of the belt to the pulley is the cause of the slip, the difficulty can frequently be overcome by using a belt dressing or by covering the pulley.

Where dry belts are the cause, or a contributing cause, of static, this difficulty may be overcome by keeping the belt "damp," that is, soft and pliable. The best way of doing this is to use a reliable belt dressing which will work into the belt and not only soften the surface but lubricate the fibers of the leather. It is well to be careful, however, and not overdo the treatment, because using too much dressing is likely to cause the belt to slip, which causes friction and again generates static electricity. In some plants operating men use a mixture of 50 per cent glycerin and 50 per cent water on the belt to keep the surface moist. However, a good belt dressing is to be preferred.

If the static electricity is not stopped by either of these methods, it can be removed with a grounded copper wire by "combing" it off the belt by means of a comb of fine copper wires suspended so as to touch or nearly touch the belt, at a point mid-way between the pulleys. When necessary, combs should be placed on both sides of the belt, but there should not be enough pressure to scratch or injure the belt in any way.

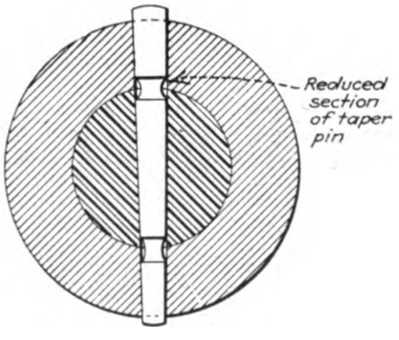
The wire leading from the comb should then be grounded to a water pipe or to anything metallic that extends down into the moist earth. Where such ground connections cannot be made to an existing structure it is sometimes necessary to drive a pipe into the ground to make the connection.

W. F. SCHAPHORST.
Mechanical Engineer,
Newark, N. J.

Using Breaking Pins to Protect Drives Against Overloads

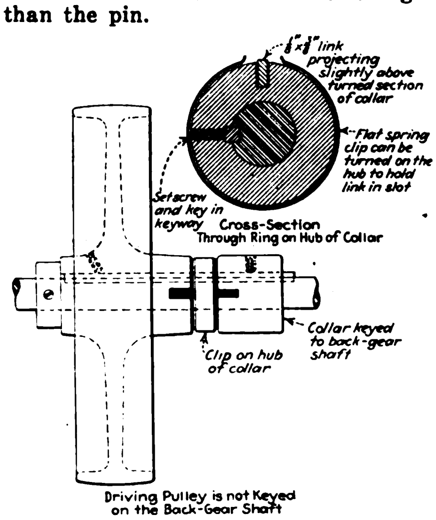
PROTECTION against overloads in mechanical drives which may be stopped suddenly is just as necessary as the fuse in electrical circuits. In many cases on belt drives the belt serves as the safety device in that it will slip or run off the pulley if the machine stops suddenly. However, if the belt tension is high the possibility of slipping is decreased also, the belt will slip off the pulley more slowly, and some part of the machine may break first. For this reason it is often desirable to place a safety link of some kind in the driving mechanism of the machine. These safety links are usually in the form of breaking pins or shear links, which have a cross-section sufficient to drive ordinary loads, but are weaker than any other part of the drive, so that they will break first and protect gear teeth or other more expensive elements of the drive. The following examples show how these links were used in three instances.

On each of a battery of duplex milling machines, a box, containing the trip, feed drive, and reverse gears, is suspended from the saddle at its front end. This box is attached by four long screws with the heads counterbored in the saddle of the tableways. This construction is neat and substantial and when assembled nothing but the line where the faces meet shows that it is a two-piece construction. However, the last member in the feed mechanism is a hardened worm that drives the hardened gear through which the splined table-screw passes. This worm is attached to its shaft with a No. 3 taper pin which serves as a breaking pin and, whenever the work jams, the hard worm on the hard shaft cuts the pin off completely. This shop uses belts of such size and under sufficient tension to make them proof against slipping, which makes the feed or drive stronger than the pin.



Method of installing a breaking pin in a gear drive.

By decreasing the cross-section of this taper pin, which holds a driving gear to its shaft, a safety link is placed in the line of power transmission. This link breaks whenever an overload is thrown on the milling machine. The pin is easily replaced.



Details of a safety link in a back-geared drive.

When the work jams this link breaks. The link, which is a piece of ⅛-in. by ⅜-in. steel, fits into a slot on the loose pulley hub and in a collar keyed to the shaft. A flat spring steel clip fits over a neck which is turned down on the end of the collar and holds the safety link in position, as shown in the sketch. An overload breaks the link and leaves the pulley free to turn on the shaft. The operator keeps a supply of extra links on hand and can replace a broken one by slipping the spring clip around, until the gap between the ends is over the slot.

When the pin is sheared, the table must be removed before the gear box can be taken off to get at the worm and replace the tapered pin. This is a heavy job either with the table stripped or with the fixtures left on and it takes two men about 2 hours to replace a broken taper pin.

The Master Mechanic decided, after a few such experiences, that, while a breaking piece was necessary, it should be located where it was more convenient. The construction was changed so that the breaks now occur at a more accessible gear outside the box, due to the weakening of the No. 3 taper pin which holds this gear to its shaft. Now, all of these milling machines have this one easily accessible spot where the taper pins have a reduced shearing section, as shown in accompanying sketch at top of page, which breaks off when an overload is thrown on the feed.

In another instance the repair man in a factory manufacturing valves and fittings had considerable trouble with threading machines jamming, due to an imperfect casting which would be too heavy for a tap or die to cut; here the threading was done on the unmachined castings.

At the first opportunity this repair man put a breaking piece on one of the machines, but instead of a taper pin he used a small piece of flat steel which was set half in each of two collars on a mainshaft on the machine. The cross-section of this strip of steel is small enough to allow it to shear off before any damage occurred elsewhere. The plan was very successful and now all these machines are so equipped.

Not long ago the writer saw a multiple semi-automatic filing machine with a simple and effective shear link. This machine was back-geared and the link was placed on the first shaft between the main pulley, which was not keyed to the shaft, and a collar keyed to the shaft, as shown in the sketch at bottom of page. The links were held in position by a circular spring clip of flat steel which was snapped around the hub of the collar. The ends of this clip were open about an inch. Turning the clip on the hub covered the link and held it in the slot or exposed the slot so that the broken link could be removed and the new one inserted.

In case a file jumped out and caught (as was sometimes the case), the pin broke. Otherwise the operator would have had the trouble of replacing a large belt on an overhead shaft 18 ft. above the floor. The operator of the machine had a supply of these links, which he could replace as quickly as he could replace a file because of the simple arrangement for holding them firmly in place.

Care must be exercised to see that the operators understand and appreciate the value of these links and do not put something in that will not break which would be the same as replacing a blown fuse with a piece of steel wire. Making it easy to replace the shearing pin or having a supply of such pins convenient, if the operator is to replace those broken, will help to insure their proper use.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

In the Repair Shop

This section is devoted to repair work on electrical and mechanical equipment. Special attention is given to shop or bench tools and short cuts or improved methods of handling work of this character. Contributions are always welcome.

Mixture for Protecting Commutator V-Ring Insulation from Oil

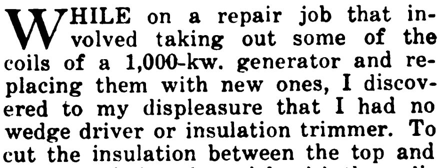
THREE years' experience of a large repair shop in the use of a mixture of plaster of paris and dextrine as an oil resisting paste to prevent the disintegration of the varnish by oil on the outer V-ring insulation of the commutator, has shown that the number of armatures coming to the shop with grounded front V-rings has been greatly reduced.

The mixture used is composed of dextrine and plaster of paris in equal proportions, with just enough liquid shellac to give it the correct consistency. It should be made thick enough to be applied with a brush, although it is much thicker than paint and other substances usually applied with a brush. A coating about 1/16 in. thick is applied to the front V-ring of the commutator.

Emergency Method of Making an Insulation Trimmer And Wedge Driver

WHILE on a repair job that involved taking out some of the coils of a 1,000-kw. generator and replacing them with new ones, I discovered to my displeasure that I had no wedge driver or insulation trimmer. To cut the insulation between the top and bottom coils is quite a job with the ordinary knife or insulation trimmer. For this reason, I made a trimmer which worked so well that I have kept it ever since as one of my regular tools.

As shown in the illustration, this insulation trimmer was made from a piece of No. 10 steel banding wire about 2 in. longer than the width of the stator iron. On one end of the wire I soldered a 125-amp. copper lug or terminal to serve as a handle. The other end of the wire was flattened and made into a V-shape, as shown. This V-shape edge was then filed to form a cutting edge.



This insulation trimmer was made of banding wire and a copper lug.

The wedge driver was made from a piece of brass tubing about 1 in. inside diameter and 1⅛ in. outside diameter. By figuring out the inside circumference of the brass tubing you will be able to get a close approximation of the correct size of the material to use as the center piece of the wedge driver. For this center piece I used fiber having a ½-in. x ⅛-in. cross-section. The brass tube was then hammered down to fit snugly around the fiber. A neat job can be made if a little care is used and the wedge driver will be found to be as good as any you can obtain. However, you must remember to work the brass tubing cold for if it is heated the tubing is very likely to crack.

NICHOLAS J. WEISS.
West New York, N. J.

Method of Changing Compound Motor to Special Series Type

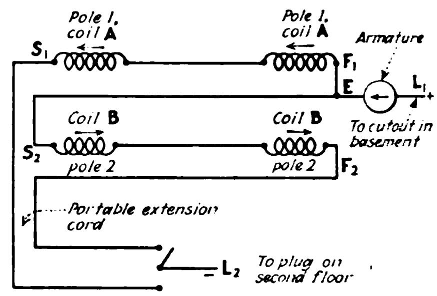
THE requirements for a certain power drive were such that it was necessary to start, stop and reverse it at some distance from the motor. It was found that a ¼-hp. motor would be satisfactory, but the customer wanted a single-pole, double-throw knife switch with a two-wire lamp cord, running from the motor for control. This was to make it easy to install and remove. It was also decided that this was a job for a series motor, which would give good torque and also permit the use of a double series field winding for two-wire control.

In the shop we had a ¼-hp., 115-volt, compound-wound motor whose fields were roasted out; so it was decided to rewind the field circuit, for the rest of the motor was in good shape. The full-load rating of this motor was 2½ amp. and the factory data gave the resistance of the two shunt coils in series as 556 ohms. Each shunt coil had 3,250 turns of one No. 30 enamel-covered wire, and each series field coil had 31 turns of one No. 20 d.c.c. wire.

The next step was to find the ampere-turns per pole. With 556 ohms across 115 volts, there would be in the shunt field circuit $115 \div 556 = 0.207$ amp., and the shunt ampere-turns per pole would then equal 0.207×3.250, or 672.75. Similarly, the series field ampere-turns equal 31×2.5 or 77.5, and the total ampere-turns equal $77.5 + 672.75$, or 750.25 ampere-turns per pole. For the series field coil to develop 750 ampere-turns at 2½ amp., it would require $750 \div 2.5 = 300$ turns per coil.

No. 20 wire was originally used for the series coils, but this was for constant duty, whereas for the new service, a double series field coil, for intermittent duty, and there would be need for all the wire space we could get. Since the wire size could be reduced, we decided to use No. 22 s.c.c. and enameled wire and wind two coils for each pole, each coil to have 300 turns. These two coils were to be taped together and four leads brought out. After assembling the coils on the two poles, they were connected up in two sections, each section consisting of two coils in series as shown in the diagram.

Next, the beginning of one section,



The motor was provided with a double series field so that it could be reversed by a single-pole, double-throw knife switch.

S_2 was connected to the finish of the other section F_1 and from their junction a tap was brought over to one brush-holder, as at E. The other brush-holder was connected to the lighting circuit L in the basement.

The lamp cord was connected to the remaining two field leads S_1 and F_2. The other end of the lamp cord was carried up to the second floor and connected to the outside points of the single-pole, double-throw switch, as shown. The middle point of this double-throw switch was connected to a single line to which an ordinary attachment plug was connected, thus leaving one prong of the plug unconnected. A plug was put in a light socket on the second floor and the plug, with one wire from the double-throw switch was tried in this socket. At the first trial the motor did not start, but by reversing the plug in the socket, the circuit was completed. By marking the plug while in this position we were able to replug the socket in the same position every time.

Then, by throwing the single-pole, double-throw switch to the left, the conditions were as indicated by the dotted-line arrows in the accompanying drawing. This reversed the polarity of the poles by sending current through the field coils of section S_1 and F_1, in the

opposite direction to the current flow in section S_2 and F_2. Since the current through the armature remained the same, the rotation was reversed. By marking one side of the single-pole switch open and the other side closed, a simple and effective control was obtained.

A. C. ROE.

Wilkinsburg, Pa.

Motor Life Increased by Dipping Coils and Baking in Electric Oven

AN INCREASE of 75 per cent in the life of motors which have been dipped and baked is not uncommon. The practice of dipping the coils of electrical equipment in an insulating varnish and baking them before placing in the machine, and then dipping and baking the complete winding, has become quite general practice in the electrical manufacturing industry and in repair shops. The Power Committee of the National Electric Light Association recently issued a report entitled "Baking Armatures and Insulated Coils in Electric Ovens." In this report it is stated that the practice first demonstrated its real value, in making savings and promoting the reliability of electrical machinery, on railway-motor armatures. Besides the direct saving involved by the dipping and baking process, there is the great gain due to fewer breakdowns in service which fact is in itself a major consideration.

The reason for the longer life and improved reliability of coils and windings that have been dipped and baked, is that the insulating varnish, properly applied and baked, forms a hard coating, impervious to moisture, which fills all the cracks and crevices, holds loose coils and laminations in place, restores coil insulation to good condition and prevents the entrance of dirt and moisture.

Proper treatment of coils and windings involves three factors: (1) Use of suitable baking varnish. (2) Thorough impregnation of the coils. (3) Uniform baking of the coils at the correct temperature.

A large part of the report is devoted to an extract from an A.E.R.A. paper, "Certain Essentials in Drying and Baking Railroad Armatures," by H. S. Day. Although this paper dealt with railway armatures, it contains much that applies equally well to industrial equipment.

The object of dipping an armature in an insulating varnish and then baking dry is to encase the wires and coils in a hard, gum substance that will, by completely surrounding the coil, prevent chafing, lessen vibration and repel moisture and oil, all of which would in time break down the original insulation and be the principal cause of grounds or short-circuits.

Three important precautions that must be observed during the process of dipping and baking are: First, the armature must be free from all dirt and moisture; second, all windings must be thoroughly saturated with varnish and the surplus drained off; and, third, the varnish must be baked dry.

To dip in varnish an armature that is not clean and dry is to defeat one's purpose at the start, because dirt and moisture trapped in windings by hardened varnish will quickly cause insulation breakdowns. The same criticism applies to the dipping of all wires and coils, for if they are not thoroughly saturated with varnish the desired result is again defeated, because it allows open spaces for the accumulation of oil, dirt and moisture.

Finally, and undoubtedly most important, if the varnish is not baked dry the coils are simply supplied with moisture before the motor has a chance to pick it up.

The universal practice in cleaning an armature preparatory to dipping is to blow the dirt out with air pressure, and this is probably the most practical, but the air must be dry air. After the dirt is all blown out, an excellent practice is to dip the armature in a vat of gasoline and move it around until all oil and dirt are removed. After the armature is cleaned, it should be placed in the oven and kept there for 10 to 12 hr. at a constant temperature just high enough to dissipate moisture that is in the coil insulation.

At the end of the preheating period the armature must be allowed to cool off, so as not to enter the varnish too hot. The correct temperature is from 55 to 60 deg. C. (130-140 deg. F.), or when a workman can comfortably lay his hand on the core. The reason for this is that if the armature is too hot the varnish will be heated, become too thin and run off, leaving the armature with too thin a coat of varnish. For the same reason the container for the varnish should be large enough to hold two or three barrels of varnish. This volume, on account of added weight, also helps in forcing the varnish further into the coils.

There are many different opinions as to how the armature should be dipped, and whether it should literally be dipped at all. But there is one point about which there cannot be any argument, and that is that the windings should be thoroughly saturated with varnish. The simplest and easiest way is to immerse the armature up to the commutator ears in a tank of varnish, with the pinion end down, for a period of 5 to 10 min.

After this operation is completed, the armature should be removed from the varnish and all free varnish drained off. In some armatures this is a little difficult to do. It may be necessary to sling the armature from both ends of the shaft and elevate first one end and then the other, at the same time giving it a few turns, continuing this operation until all the free varnish has run off. Ordinarily the average armature will drain properly if set upon the pinion end of the shaft and allowed to stand 10 or 15 min. The important thing is to get rid of the free varnish, so that there will be no pockets of wet varnish to cause trouble during the baking period.

Equally as important as having the armature at the right temperature when it is placed in the varnish, is to have the varnish at the right specific gravity. About the most practical way of ascertaining the correct specific gravity is to use a hydrometer. Most varnishes can be thinned or, as it is called, "cut" by the use of gasoline or benzine. This should be added in small quantities and stirred in, because if a large amount of gasoline is added at one time curdling of the varnish may result. Gasoline or benzine that has a low kerosene content should be used, as when the kerosene content is high the oil is left when the gasoline is evaporated during the baking period. Gasoline to be used as a cutting agent should test not less than 54-46 deg. Baumé.

By using a hydrometer the uniformity of the varnish can easily be controlled. This is necessary if the results are to be uniform. Having once established that specific gravity which gives the best filling results and the best penetration, any deviation from that point will result in a loss of one or the other of these characteristics.

When the armature is drained it should be placed in an oven in which the temperature generally recommended is not allowed to vary either below 115 deg. Cent. (239 deg. F.), or above 125 deg. C. (257 deg. F.), and kept there without interruption until the baking period is over. It is an excellent practice if the armatures are placed in a horizontal position to turn them every 10 to 15 min. during the first hour before the varnish is set. This will prevent what free varnish is left from collecting in one spot.

The oven must be ventilated sufficiently to carry off the moisture and gases given off in the baking process without lowering the temperatures, and the baking period should be uninterrupted; that is, the oven not cooled down until the varnish is dry.

The varnish must be baked dry, whatever the time required, and the baking time is, of course, governed to some extent by the oven temperature. A simple way to know when an oven is baking armatures dry is to measure the insulation resistance during the baking period.

This should at least be done in starting a new oven, and from time to time until the operator has established standards and becomes thoroughly familiar with every detail that is connected with this process.

There are two types of baking varnish, one having a Chinawood oil base, and one a linseed oil base. Varnish with a linseed oil base will not give as good results as a combination varnish containing a larger proportion of Chinawood oil than linseed oil. This is a matter for the operator to decide by the results obtained. The same thing may be said in choosing between amber and black varnishes, although it is believed that more gums and non-volatile insulating substances, such as asphalt, can be suspended in the black varnish. The important thing is to select a varnish that is known to be high grade and is made for the specific purpose of being baked on coils.

Ovens should be thermostatically controlled to insure a constant temperature during the baking period because if controlled by hand and left to an operator the heat control will be frequently forgotten or neglected, and it is important that this should not happen for otherwise the quality of the insulation will be impaired.

Practical Books

for your personal library

Every man who aspires to larger responsibilities should build up a professional library containing carefully selected volumes on subjects related to his work. Copies of the books which are reviewed here may be obtained from the publishers mentioned.

Electric Transients—By Carl Edward Magnusson, Professor of Electrical Engineering and Director, Engineering Experiment Station, University of Washington. Published by McGraw-Hill Book Company, Inc., 370 Seventh Ave., New York, N. Y. Cloth; 6 x 9 inches; 237 pages; illustrated. Price $3.

The purpose of this book is to aid the student in gaining clear concepts of the fundamental principles underlying transient electric phenomena and their application to quantitive problems. The text is illustrated and supplemented by a large number of oscillograms of transients that occur in the various types of machines and electric circuits in common use in electrical engineering laboratories.

* * * *

Belt Conveyors and Belt Elevators—By Frederick V. Hetzel, M.E. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York, N.Y. 333 pages; 6 x 9; illustrated. Price $5.

In this, the second edition of this book, the author presents his experience in such a form as to be useful to men who have material to handle and who want to know more of the how and why of conveying and elevating by belts, than can be told in catalogs and advertisements.

The information given will be of use also to consulting engineers who have to advise in the selection of the proper machinery to do certain work, to engineers and draftsmen who design such machinery, and also to students in technical schools and colleges.

* * * *

Industrial Safety Organization—By Lewis A. DeBlois, Director, Safety Engineering Division, National Bureau of Casualty and Surety Underwriters. Published by McGraw-Hill Book Co., Inc., 370 Seventh Ave., New York, N. Y. Cloth; 6 x 9 inches; 328 pages; illustrated. Price $4.

This book presents a thorough, practical discussion of the fundamentals and basic principles of safety organization. The purpose is to furnish industrial executives with information about the industrial safety movement and the essential principles of safety work needed for successful accident prevention. It aims also to provide safety engineers with a technique based on sound and logical principles.

Fourteen years of accident prevention work in the du Pont Company, where safety organizations were developed from modest beginnings in numerous small plants to full-fledged safety departments competent to function satisfactorily in huge war-time establishments—these later to pass through successive stages of retrenchment and expansion—have permitted the author to make a broad survey of safety systems and methods, successful and otherwise.

* * * *

Electrical Characteristics of Transmission Circuits—Compiled by William Nesbit, Manager, Engineering Division, New York Office, Westinghouse Electric & Manufacturing Company, published by Westinghouse Technical Night School Press, East Pittsburgh, Pa. Cloth; 9 x 12 inches; 317 pages; 102 tables; 28 charts; 100 figures. Price $6.

The rapid expansion in the use of electrical energy necessitates a tremendous amount of arithmetical labor in connection with the solution of projected transmission and distribution circuits. This demands much valuable time and energy of the engineer, and in the education of young engineers in our technical schools. It is largely to assist these by making their work easier and less liable to error, and by providing them with all the necessary tools, that the data in this book have been compiled.

The user of this book is provided with numerous and extensive tables of circuits and other constants which make it unnecessary for him to lose time or risk mistakes in calculating constants for each case in question. Every effort has been made to simplify explanations by the aid of supplementary diagrams and tabulations.

* * * *

Engineering Metallurgy — By Bradley Stoughton, Professor of Metallurgy, Lehigh University. Published by McGraw-Hill Book Co., Inc., 370 Seventh Ave., New York, N. Y. Cloth; 6x9 inches; 441 pages; illustrated. Price $4.

In this, the first volume of the new series of metallurgical texts, the subject of metallurgy is approached from the standpoint of utilization, with the purpose of giving the reader an understanding of the relations of structures and properties, methods of investigating them, their relation to uses, their modification through mechanical and heat treatment, the effect on them of the principal impurities, and the effect on them of differences in production processes.

This is a practical book and is in reality a textbook for users of metals, and is well worth while for the men interested in this subject.

* * * *

Standard Wiring—By H. C. Cushing. Published by H. C. Cushing, Jr., 15 West Fiftieth Street, New York, N. Y.

In the November issue of INDUSTRIAL ENGINEER, the price of this book was quoted as being $2.50 per copy. This price applies only when lots of two to four copies are purchased. The price per single copy is $3.

New Equipment

for plant operation and maintenance

Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these new devices which are designed to improve plant operation or reduce operating and maintenance costs.

Heavy-Duty Chain Belts

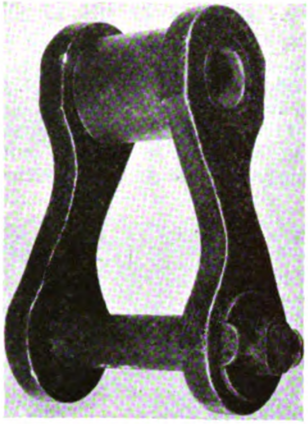
TWO new oil well chains for heavy-duty service, with the trade name of Rex Deep Well Chabelco 1240-D.W.4 and 1030-D.W.3, which have a new type of pin lock and high tensile strength, together with ground pins and ground bushings, have been announced by the Chain Belt Co., Milwaukee, Wis. The rated strength of these chains is given as 90,000 lb. for the 1240-D.W.4 and 45,000 lb. for the 1030-D.W.3. This represents an increase of 25,000 lb. in 1240 and 15,000 lb. for the 1030 over the old chains of that number, although the new chains are of the same weight and pitch as their predecessors, it is stated.

The Rex pin lock offered on these chains is said to be entirely new and is designed to replace the cotters ordinarily used. In oil well drilling and similar heavy-duty service the cotters, in a relatively short time, either break or jump completely out of the chain. The pin then works loose rapidly from the drive fit with which it is seated in the sidebar. The new Rex pin lock, it is stated, is as simple to use as the cotter. It consists of a disk which fits over the link pin, which is a short spring pin that is slipped through the hole in the link pin and secured at each end by bending up the two metal ears on the disk. This construction is easily seen in the accompanying illustration.

The link pins have also been improved; the drop-forged steel pins are ground on a centerless grinder and the bushings are made from seamless drawn tubings. The natural action of the chain, according to the manufacturer, is freer, friction is reduced, and the wearing qualities of the chain are

increased by bringing these smooth surfaces together. The ground pin allows much closer fitting of the pin and bushing and the ground bushing and the roller also operate with closer clearances. The bushings have one flat milled on each end and are forced into the sidebars under pressure.

With the smooth surfaces of both

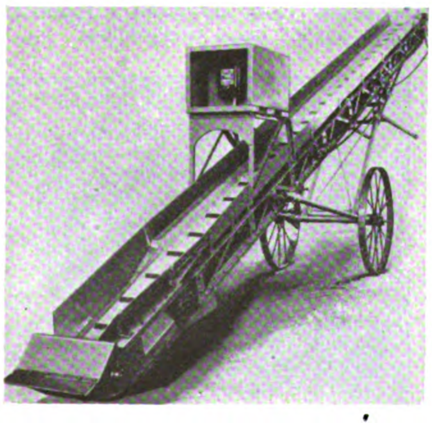


the pins and sidebars, the manufacturer states that it is not necessary to make allowances for variation or rough spots either in the pins or in the interior so that while these chains are more flexible, the pitch is far more accurate. The results claimed for this construction are longer life and correct distribution of strain and stress between the chain, sprockets, and other working parts that are chain driven. All parts are heat-treated.

Improved Portable Conveyor

AN IMPROVED type of portable belt conveyor for handling sand, gravel, crushed stone, bricks, coal, coke, and similar materials has recently been put on the market by the Jeffrey Manufacturing Co., Columbus, Ohio. Improvements have been made with the idea of providing a machine more suitable for industrial plants and building material yards, where it is desired to handle materials from hopper bottom railroad cars to storage piles or trucks, and for reclaiming from storage piles.

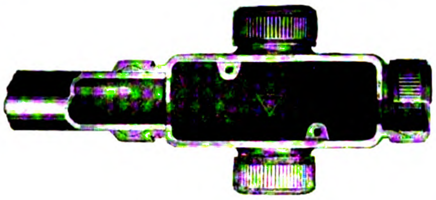
Four new features are incorporated in this new conveyor. Steel side boards, which are bent to extend under the side of the belt, forming with the belt a moving trough, provide larger capacity and prevent lumps from rolling off. An improved type of carrying idler supports the loaded portion of the belt. An extended and flared loading leg at the bottom edged with belting forms a seal with the moving belt. The flared hopper also centers the load on the conveyor. An efficient gate at the foot of the conveyor prevents materials from falling into the inclosed boot housing.



An easily-operated screw adjusts the elevator to any convenient height. The foot of the conveyor is so low that it will readily enter a pile of loose material. The conveyor is built in 18-, 24- and 30-ft. lengths, and is furnished with an electric motor or gasoline engine.

No-Thread Unilets

IMPROVEMENTS in its line of No-Thread Unilets have been announced by the Appleton Electric Co., 1701 Wellington Ave., Chicago, Ill. These will be manufactured as an addition to the line of threaded Unilets made by this company. No-Thread Unilets of a different design were made by this company more than 15 years ago and the new line, it is stated, shows many decided improvements over the old. There are no loose parts. To install, according to the manufacturer, it is only necessary to cut the conduit, slip it into the No-Thread Unilet, tighten



the knurled nut, which insures a mechanically secure joint, a running ground and a strong job, in considerably less time than is ordinarily required.

The accompanying sectional view of this improved Unilet shows its design. The tapered steel ring is squeezed into the conduit by the knurled nut. This same ring has on its inner surface three projecting beads that pierce through the conduit enamel, thus establishing a metal-to-metal contact and insuring a perfact running ground, it is stated. All standard Unilet covers and fittings are interchangeable with the No-Thread Unilets.

Armature Feeler Gage

A NEW feeler gage has been placed on the market by C. A. Parkham, Inc., 526 W. Fort St., Detroit, Mich., for use in checking the gap between stators and rotors.

The feeler stock is manufactured from imported Swedish tempered steel feeler stock, which is represented as having an accuracy to within 0.0001 in.

The blades and handle are each 16 in. long, making an overall length of 32 in.; the blades are 0.06, 0.08, 0.010, 0.015, 0.025 in. in thickness. Should it be necessary to replace a blade it can be easily removed by loosening a screw in the handle.

Heavy-Duty Belt Clamp

CLAMPS of a new design for joining fabric base belts in heavy-duty service have been announced by the Victor Balata & Textile Belting Co., 38 Murray St., New York, N. Y. These are known as the Petrol belt clamp and were originally developed to increase the life and service of oil well drilling

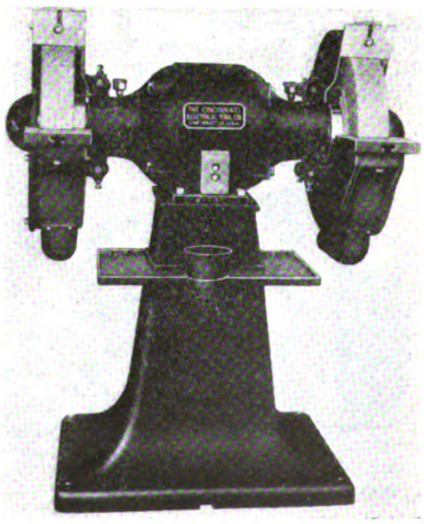
and pumping belts which operate under extremely severe service. These clamps are also used for exceptionally severe industrial service.

The type of clamp and its application are shown in the accompanying illustration. The clamps are made of steel forgings and are bolted together with carriage-style bolts, hexagon nuts and lock washers. The clamp and fittings are galvanized. Corrugations on the jaws of the clamp give a better grip on the belt, it is said, and so help to prevent tearing. Also, the clamps are curved at the angle. This, according to the manufacturer, prevents the clamp from cutting the belt and also avoids misapplication.

Fully-Enclosed, Heavy-Duty Floor Grinder

THE Cincinnati Electrical Tool Co., Cincinnati, Ohio, has recently added to its line of portable electric drills, grinders and buffers, new 2- and 3-hp. fully-enclosed, heavy-duty, ball-bearing, floor grinders suitable for grinding of all kinds.

The ball bearings are mounted in dustproof housings, and it is stated, are correctly locked to the shaft to provide for end thrust and eliminate shaft wear. The spindle is of high-grade steel turned and accurately ground to size. Wheel flanges and nuts are machined to be in perfect balance with the spindle. Removable covers bolted to the guard completely enclose the side

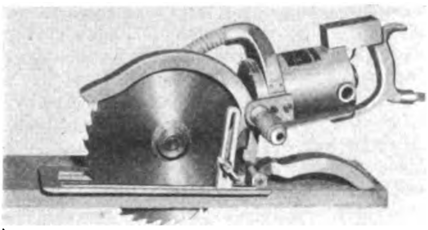


of the wheel, flanges and nuts, insuring safety to the operator. The 2-hp. grinder is equipped to carry 12-in. by 2-in. by 1¼-in. wheels and the 3-hp. grinder, 14-in. by 2½-in. by 1¼-in. wheels.

These grinders may be obtained for operation on either alternating current, 220 or 440 volts, 25 to 60 cycles, two- or three-phase, or direct current, 115 or 230 volts.

Electric Hand Saw

INDUSTRIAL plan men and contractors who have occasion to do more or less sawing of wood outside the wood shop will be interested in the announce-



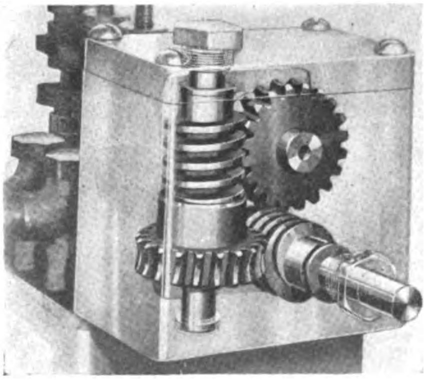
ment of the Wodack Electrical Hand Saw, shown in the accompanying illustration, which is manufactured by the Wodack Electric Tool Corp. located at 23-27 South Jefferson Street, Chicago, Illinois.

This electric tool weighs 24 lb. and is fitted with a motor which is said to be large enough to drive an 11-in. circular saw and yet can be operated from an electric light socket. Industrial men are finding use for this saw it is stated, for removing flooring; electrical construction men are using the saw for cutting a channel in the floor in which to lay conduit, and many other uses are reported, such as for concrete form work, in the shipping room, and so on.

The saw is fitted with a depth gage so that the depth of the cut can be closely controlled, as when cutting through a floor or opening a box or crate.

Fractional Horsepower Worm Reducers

COMPLETION of the design and the marketing of a ¼-hp. worm speed reducer is announced by the Hills-McCanna Co., 2025 Elston Ave., Chicago, Ill. A phantom view of one of the double-reduction units is shown in the



accompanying illustration. This equipment was originally designed for use in connection with the drive of the Hills-McCanna force-feed lubricating system. The 20: 1 and 30: 1 reduction units are made in the single-reduction worm and gear types. A double combination of worms and gears is used to obtain reductions of 50: 1, 100: 1, 200: 1 and 400: 1.

The manufacturer states that standard, hardened steel worms running against bronze worm gears are used. The whole mechanism is enclosed in a grease-packed, dustproof case measuring 4 in. by 4 in. by 2½ in. The case is provided with stuffing boxes to retain the grease. A ½-in. shaft is provided for connecting to a motor through a flexible coupling or for belt drive.

Rapid-Heating Melting Pots

AN ADDITION to the Trent line of rapid-heating melting pots manufactured by Harold E. Trent, 250-261 N. Lawrence St., Philadelphia, Pa., is shown in the accompanying illustration. This pot, it is said, is suitable for melting babbitt, solder, lead, and tin, and has a capacity of 10 lb. The pot is for use on 110 or 220 volts, a.c. or d.c., and can be connected to a lamp socket. A new feature of this equipment is that a new design of protected plug contact has been added whereby

a standard plug can be used to obtain the three-heat combination.

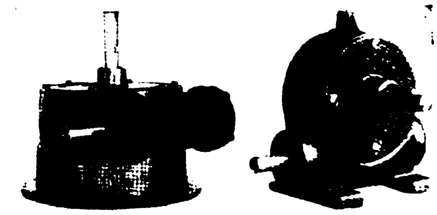
All pots are fitted with spouts and two handles to facilitate pouring metal, if so desired. The crucible is insulated to give high heat efficiency, according to the manufacturer.

Reducing Gears of Small Capacity

ANNOUNCEMENT is made that Winfield H. Smith, Springville, N. Y., has added two new uits to his line of reducing gears of small horsepower capacity. One of the new models is the No. 8 vertical-drive, worm gear reduction unit, which is shown in the accompanying illustration above. The same reductions of 40:1, 20:1, or 10:1 can be furnished as are standard with the horizontal-drive, No. 8 reducing gear. Ratings for the various reductions are 2, 3 and 5 hp. respectively, at 1,800 r.p.m. of the worm shaft. The illustration shows the driven shaft extended at the top, but if desired the shaft can be extended and the drive taken from the bottom. This type of drive is used, it is said, in connection with mixing machines, agitator tanks, turntables, and so on.

The other new reducing gear, shown at the right is the No. 2½ unit, which is made for use with motors up to ¼-hp. capacity. Standard units are built to give a reduction of 40:1. The unit is 5½ in. high from the bottom of the base to the top of the housing and weighs 8 lb. Bronze bearings are used for the high-speed shaft.

In addition, the standard No. 3 reducing gear has been redesigned as the No. 3 A, but all of the essential dimensions are the same as in the old unit. This reducing gear is for use with motors

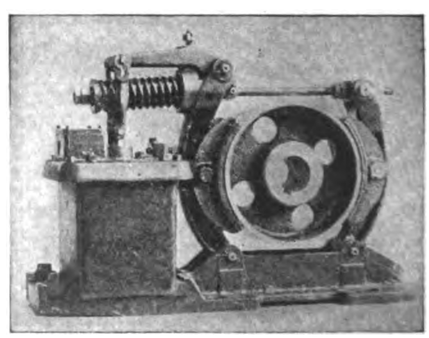


up to ⅓-hp. capacity. Reductions of 20:1, 10:1 and 5:1 are standard and units are carried in stock for immediate shipment.

New Magnetic Brakes

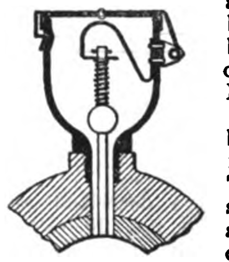
TWO new magnetic brakes, types DI and AI, are being manufactured by the Westinghouse Electric and Manufacturing Company for both direct-current and alternating-current service. In addition to being spring-set and easily adjustable, these brakes have unusually small dimensions, a distinct advantage for industrial applications. The small diameter of the brake wheel requires less power to operate and less time for starting and stopping.

A weatherproof cast-steel housing for the magnet, is another feature of these brakes. The magnet and coil unit are protected against damage and the weather. Ample ventilation is provided for by hooded openings in the cover of the housing, and cored holes in the base. The complete magnet can be removed from the brake by simply taking out one pivot pin and loosening two bolts in the tapered blocks, and a new magnet substituted in a very short time. With this design the same equipment may be used for both alternating-current and direct-current work by merely changing the magnet. A manual release enables the motor to be operated without the brake during inspection or test.



Grease Lubricator

EXPERIMENTAL and development work have been completed on the Knorr lubricator which is shown in the accompanying illustration, according to an announcement by the Knorr Lubricator Sales Co. of New England, 80 Federal St., Boston, Mass., and distribution to industry is now under way. This lubricator consists of a cup with a spring cover to contain the grease.



The lubricant is fed down to the shaft between the pin and the oil hole by the movement of the pin, which rests on the shaft, due to the eccentricity of the shaft. The spring on the pin maintains contact with the shaft. This device, it is stated, feeds the grease much in the same manner as the bottle oiler feeds oil. An advantage claimed is that feed of the lubricant takes place only while the shaft is in motion, and in a degree corresponding to the speed of the shaft.

Mica Insulation

A NEW mica insulation, called "Super-micanite," has been developed by the Mica Insulator Company, 68 Church Street, New York City. The development of a synthetic insulating cement, a resin produced from glycerine and phthalic anhydride, which possesses electrical and chemical characteristics particularly advantageous as a cement for mica insulating materials, has resulted in the further development of "Super-micanite." This new insulation is said to be ideally adapted for commutator insulation.

The outstanding advantages of "super-micanite" as compared with shellac-pasted mica are listed by the manufacturer as follows: It is non-corrosive to copper; its binder decomposes at high temperatures and then produces decomposition products which are neither corrosive nor conducting; it shows practically no slippage under pressure; its surface resistivity is approximately 350 per cent greater; it has higher dielectric strength; its loss factor is approximately 43.5 per cent of that of shellac-pasted mica; its volume resistivity is approximately 92 per cent higher; it has a greater resistance to moisture; it has more compressive strength than shellac-pasted mica up to 100 deg. C.; it has a lower moisture content and a greater transverse strength.

Variable-Speed Transmission

TWO new variable-speed transmissions have been added to the line of this equipment manufactured by Reeves Pulley Co., Columbus, Ind. The first, as shown in the upper illustration of Fig. 1, consists of a constant-speed motor mounted on and above the Reeves variable-speed transmission and connected to the input shaft by a silent chain. This not only makes a compact installation, but conserves floor space in that it is not necessary to mount the motor on the floor alongside the transmission or drive down from the ceiling. This motor mounting is slotted and, it is said, will accommodate any standard type of motor of the proper size for the drive. Adjustments can be made by means of the slot to give the proper tension on the chain drive.

This unit is marketed under the name of Reeves Compact Motor Drive. The unit is ball-bearing equipped and force-feed lubricated. The transmission receives power at a constant speed and delivers that power at any speed desired between the rated fastest and slowest speeds over a range as high as 16:1. By means of clutches or an extra shaft this ratio may be increased. The speed may be maintained at any set point or varied manually or automatically. The unit may be mounted on the floor, or built into the machine.

For installations where space is too limited for the use of the Reeves Compact Motor Drive, the vertical type of transmission shown in the lower illustration of Fig. 1 was developed. The shifting screw is generally located at the top of the drive and the speed may be varied either manually or automatically and the speed indicator used, as is standard with all types of Reeves transmission.

The improved type of splice blocks shown in the other illustration, facilitates the removal or application of the standard, rubber body V-belt to the transmission. The V-belt is made up of a rubber belt body to which is attached at regular intervals hardwood blocks, tapered at both ends and faced with leather to conform to the V-angle of the disks. As shown in this illustration the splice block is made up of two half-sections of the block with hinge plates at each end of the belt. These hinge plates are screwed to the blocks at each end and secured by inserting pins through the eyes of the hinge. Corresponding hinges are attached to the tooth side of the block as well as to the belt side.

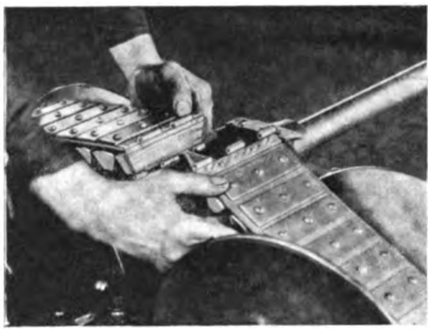
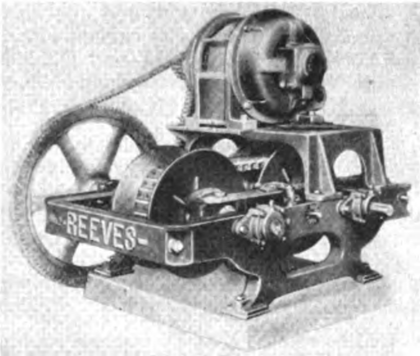


Fig. 2—Improved type of splice block manufactured by Reeves Pulley Co.



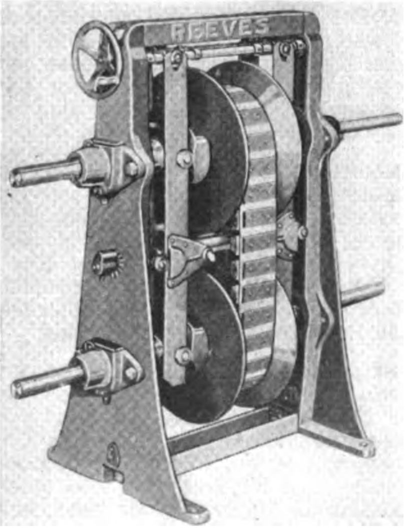


Fig. 1—Above, Reeves Compact Motor Drive. Below, vertical type transmission

Self-Starting Squirrel-Cage Motor

DEVELOPMENT of the type H-O (Hanson-Oesterlein) self-starting squirrel-cage motor, has been announced by the Northwestern Mfg. Co., Milwaukee, Wis. This motor has a single rotor winding with the rotor bars near the surface, thus giving a minimum magnetic leakage, it is stated. The rotor bars are connected at the ends to low-resistance, arc-welded, copper end rings. These are partly surrounded by steel laminations. For motors requiring a high starting torque high-resistance end rings are placed next to the rotor core. During the starting period the high impedance in the low-resistance end rings prevents the flow of current in them and forces it through the high-resistance end rings, thus producing a high starting torque, according to the manufacturer. As the speed increases the impedance in the low-resistance end rings decreases and the total torque increases until the rotor reaches full speed.

These motors are built regularly for two torque ratings. The type H-O-L, it is stated, has a 130 per cent starting torque and is suitable for motor-generator sets, centrifugal pumps, fans or for any machinery requiring low starting torque. The type H-O has a 200 per cent starting torque and is used for driving air compressors, refrigerating machines, plunger pumps and other machines requiring high starting torque. The rating is 40 deg., continuous duty. It is stated that a single-throw switch may be used for starting small motors and a push-button-operated switch with overload and no-load protection for 15-hp. and larger motors.

Power Transmission Association Elects Officers

THE second general meeting of the Organization Committee of the Power Transmission Association was held Wednesday, November 17, at the Pennsylvania Hotel, New York, N. Y., with representatives present from a large number of leading manufacturers of mechanical power transmission and allied equipment.

W. H. Fisher, chairman of the Organization Committee, presided and after the meeting had been called to order introduced Frazer M. Moffat, president of the Tanners Council of America and E. J. Mehren, vice-president of the McGraw-Hill Publishing Company, who spoke briefly on the ideals and purposes of trade associations, and their value in promoting closer co-operation in the solution of problems that are of mutual interest.

Chairman Fisher then presented the report of the Organization Committee, in which it was shown that a great deal of interest had been evinced in the purposes of the Association by manufacturers in this industry, and that to date 104 companies had signified their intention of joining. The report also contained recommendations covering the form of organization which it was felt would be most suitable for this Association and proposed a schedule of dues for member companies.

After the reading of the report, there was some discussion as to the advisability of having the Organization Committee continue its work, so that a larger number of members could be secured before the Association proceeded to carry out its program. When this question was put before the meeting, however, it was unanimously voted to put the Association on a permanent basis and have it undertake active work at once.

Upon receipt of the report of the Nominating Committee appointed by the Chairman, the following officers were elected:

President. W. H. Fisher, secretary and sales manager, T. B. Wood's Sons Co.

Vice-presidents. representing,

- Leather Belting Manufacturers, F. H. Willard, president, Graton & Knight Mfg. Co.
- Tanners and Curriers, Edward D. McKown, vice-president, Hans Rees' Sons Co.
- Power Transmission Equipment Manufacturers, Geo. H. Miller, president, Dodge Mfg. Corp.
- Pulley Manufacturers. Wm. R. Simpson, vice-president, The American Pulley Co.
- Hanger Manufacturers, S. A. Ellicson, president, Chicago Pulley & Shafting Co.
- Accessory Manufacturers, Wylie K. Lee, president, Clipper Belt Lacer Co.
- Fabric-base Belt Manufacturers, B. J. Kielly, president and general manager, R. & J. Dick Company.

Treasurer, L. H. Shingle, president, Shingle-Gibb Leather Co.

Trade Literature

you should know about

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Service Switches—A booklet describes type WK-54 Westinghouse meter service switches.—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Transformer Tap Changer—Bulletin 2055 describes and illustrates the construction and operation of the Pittsburgh transformer tap changer.—Pittsburgh Transformer Co., Pittsburgh, Pa.

Motor Maintenance Equipment—In Catalog No. 7 there are descriptions and illustrations of the various types and applications of equipment used in motor maintenance.—The Martindale Electric Co., P. O. Box 2660, Cleveland, Ohio.

Paint and Painting Equipment—Leaflet VA-1 describes Vortex industrial paints and illustrates the application of the mechanical painting equipment.—The Vortex Manufacturing Co., 1978 W. 77th St., Cleveland, Ohio.

Circuit Breakers—Leaflets L 3549-B, L 20135-A, and L 20011-A discuss the application, construction, and operation of types CA, CL and CN carbon circuit breakers, and types F-11 and F-22 oil circuit breakers.—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Starting Equipment—Bulletin 600 describes the Allen-Bradley primary resistance starters. Bulletin 710 describes the type J-1552, form T, across-the-line starting switch. Bulletin 740 describes the type J-3052 automatic resistance starter.—Allen-Bradley Co., Milwaukee, Wis.

Waterproofing and Damp-Proofing Concrete—Folder No. 2 gives complete descriptions and detailed specifications of waterproofing, damp-proofing, and allied products for use with mass concrete and cement mortar, or for surface application.—The Master Builders Co., Cleveland, Ohio.

Controls—The fourth issue of Mill Motor Gossip describes and illustrates, Clark magnetic brakes, flexible couplings, manual controllers, starting switches, and resistors, with references to bulletins containing more complete information.—The Clark Controller Co., 1146 E. 152nd St., Cleveland, Ohio.

Skip-Lift—Bulletin 79 describes and gives the operating features claimed for the Beaumont Skip-Lift for handling granular materials, such as coal, stone, and so on, in bulk. Numerous sketches and illustrations show typical installations under a wide variety of conditions.—R. H. Beaumont Co., Philadelphia, Pa.

Portable Grinders—Nos. 2, 3, and 4 ball-bearing, floor-type, electrically-operated grinders are described and illustrated in Circular No. 36.—Binghamton Flexible Shaft Co., 239-241 Water St., Binghamton, N. Y.

Air Filters—The advantages and necessity for pure air are discussed and Sirocco air filters described and illustrated in Bulletin No. 2223.—American Blower Co., Detroit, Mich.

Electric Hammers—Simbi hammers together with their various applications, are described and illustrated in Bulletin 106.—The Rawlplug Co., Inc., 66 W. Broadway, New York, N. Y.

Hand Lift Truck—A circular entitled "Multiplying Men" describes some of the features of construction of the model K Stuebing all-purpose, hand-lift truck.—Stuebing Truck Co., Cincinnati, Ohio.

Pneumatic Conveying—Bulletin 515 describes the use of a Dracco pneumatic conveying system for unloading, conveying and reclaiming alum.—The Dust Recovering & Conveying Co., Harvard Ave. & E. 116th St., Cleveland, Ohio.

Lighting—Catalog 47-A gives instructions and helpful illustrations for planning industrial lighting installations. Catalog 47-b describes and illustrates various types of lights.—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Roller Bearing Data—A 64-page book contains descriptive and illustrative matter covering the application of Timken bearings to all kinds of automotive, transportation and industrial machinery.—The Timken Roller Bearing Co., Canton, Ohio

Worm Gear Speed Reducers—Bulletins 251, 261 and 263 describe the Horsburgh and Scott horizontal and vertical worm gear speed reducers and shows the special features in their construction.—The Horsburgh & Scott Co., Cleveland, Ohio.

Blowers—A complete description of American H. S. Fans, Class 15M, is contained in Bulletin No. 7003, together with illustrations of the different parts of the blowers, air capacity tables and drawings of the blower housings which are accompanied by tables showing the outside dimensions of the various sizes of blowers.—American Blower Co.. Detroit, Mich.

Carbon Products—Announcement is is made that a new film entitled, "Behind the Pyramids" has been prepared which shows the manufacture, application, operation and care of carbon products used in the electrical industry. Arrangements for showing this may be made by writing to the Carbon Sales Division of this company.—National Carbon Co., Inc., Cleveland, Ohio.

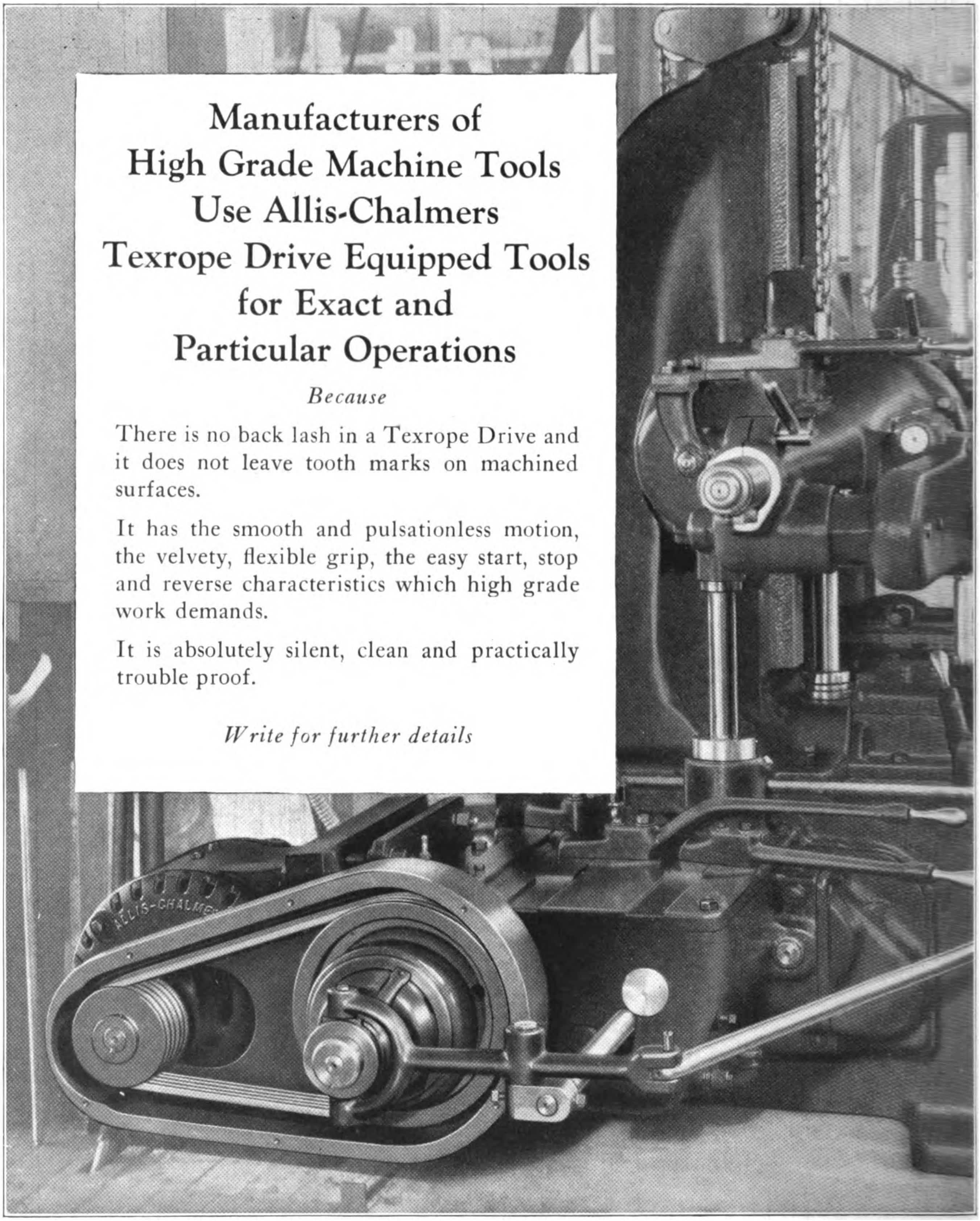
Founded 1882 as
The Electrical Review

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

McGRAW-HILL PUBLISHING COMPANY, INC.

December, 1926


Manufacturers of
High Grade Machine Tools
Use Allis-Chalmers
Texrope Drive Equipped Tools
for Exact and
Particular Operations
Because
There is no back lash in a Texrope Drive and it does not leave tooth marks on machined surfaces.
It has the smooth and pulsationless motion, the velvety, flexible grip, the easy start, stop and reverse characteristics which high grade work demands.
It is absolutely silent, clean and practically trouble proof.
Write for further details
ALLIS-CHALMERS

Volume 84 New York, December, 1926 *Number 12*

G. A. VAN BRUNT
Managing Editor
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Consulting Editor

INDUSTRIAL ENGINEER

Founded in 1882 as Electrical Review with which was consolidated Western Electrician

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

F. E. GOODING
A. J. WHITCOMB
G. H. FAIRBANKS
Associate Editors

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What Does Advertising Mean to You?

IN HIS recent address before the American Association of Advertising Agencies, President Coolidge expressed in the following words what will come to many as a new concept of the purpose and importance of advertising:

When we stop to consider the part which advertising plays in the modern life of production and trade we see that basically it is that of education. It informs its readers of the existence and nature of commodities by explaining the advantages to be derived from their use and creates for them a wider demand. It makes new thoughts, new desires, and new actions. By changing the attitude of mind it changes the material condition of the people.

Under the stimulation of advertising the country has gone from the old hand methods of production, which were so slow and laborious, with high unit costs and low wages, to our present great factory system and its mass production, with the astonishing result of low unit cost and high wages.

The pre-eminence of America in industry, which has constantly brought about a reduction of costs, has come very largely through mass production. Mass production is only possible where there is a mass demand. Mass demand has been created almost entirely through the development of advertising.

In former days goods were expected to sell themselves. Oftentimes they were carried about from door to door. Otherwise, they were displayed on the shelves and counters of the merchant. The public were supposed to know of these sources of supply and depend on themselves for their knowledge of what was to be sold.

Modern business could neither have been created nor can it be maintained on any such system. It constantly requires publicity. It is not enough that goods are made: a demand for them must also be made. It is on this foundation of enlarging production through the demands created by advertising that very much of the success of the American industrial system rests.

McGRAW-HILL PUBLISHING COMPANY, INC., Tenth Ave. at 36th St., New York, N. Y

JAMES H. McGRAW, President
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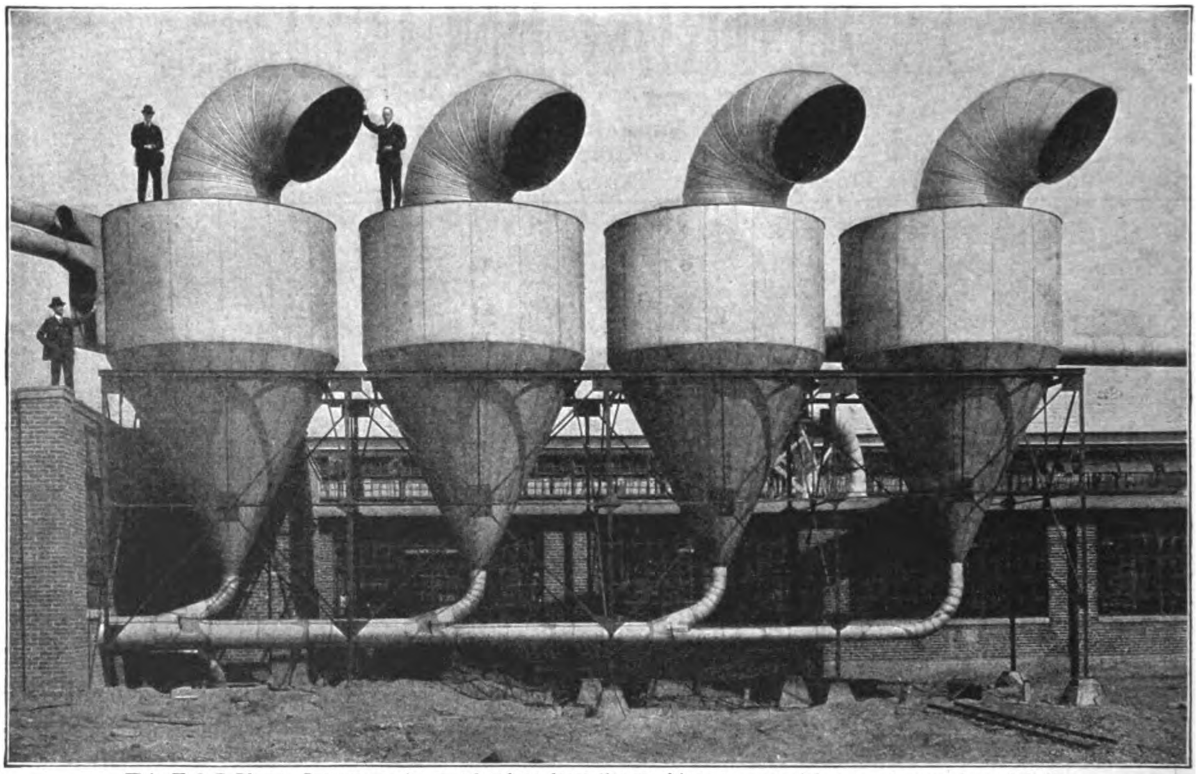
Coal Age — Engineering and Mining Journal
Ingeniería Internacional — Successful Methods
Bus Transportation — Electric Railway Journal
Electrical World — Electrical Merchandising
Industrial Engineer — Radio Retailing
Journal of Electricity
(Published in San Francisco)
American Machinist—European Edition
(Published in London)

The annual subscription is $2 to any part of the United States, Canada, Mexico, Alaska, Hawaii, the Philippines, Porto Rico, Canal Zone, Cuba, Honduras, Nicaragua, Peru, Colombia, Bolivia, Dominican Republic, Panama, El Salvador, Argentina, Brazil, Spain, Uruguay, Costa Rica, Ecuador, Guatemala, Parguay, Chile and Haiti. Extra postage to other countries, $1 (total $3, or 13 shillings). Single copy, 25 cents. Change of Address—When change of address is ordered the new and the old address must be given. Notice must be received at least ten days before the change takes place. Printed in U. S. A. Copyright 1926 by McGraw-Hill Publishing Company, Incorporated. Published monthly. Entered as second-class matter June 7, 1926, at the Post Office at New York, N. Y., under the Act of March 3, 1879.

SAVING MACHINES, MOTORS, MEN AND MONEY BY BETTER DUST REMOVAL



This K & B Blower System carries wood refuse from the machines to a special power house where 4 boilers generating 600 hp. supply all heating and process steam and part of the factory power.

Better Designed Blower System Saves $9,360 Yearly

The new K & B book "Blower Systems," is a complete description of the most approved design, construction, and applications of dust-collecting equipment in wood-working and metal-working plants, glass, chemical and other industries. Send the coupon for a copy today.

Geo. F. Kroeger, Gen'l. Supt. Globe-Wernicke Division of Rand-Kardex Bureau, Inc., Cincinnati, says:

"Cutting 35,000 feet of lumber a day formerly made our mill room men look like millers, but since we put the problem up to Kirk & Blum to install a complete blower system to remove dust and refuse, many of the men wear white shirts.

"Greater cleanliness means greater efficiency, in our case it has resulted in less repairs and longer life for machines and motors, fewer accidents to men and machines, improved quality of output, lowered labor turnover, less absenteeism and better morale.

"We have had no shut-downs for repair on hundreds of feet of K & B piping, and in six years we have spent only $15.00 on patching one elbow that had the hardest wear.

"We found that the better Kirk & Blum engineering features make our present blower systems require 20% less power than our old system— which at $45 per horsepower year means a yearly saving of $3,960. This more thorough system also saves us 30%, or $2,700 a year on cleaning labor, $900 on hand trucking, and $1,800 on carting heavier refuse now put through the waste hog and blown through the pipes. This traceable money saving of $9,360 each year is nearly three times the depreciation and interest on our K & B equipment. Some managers forget that the annual power cost may easily run 50% of the first cost of a blower system, and that a cheaper system may easily mean much higher real cost than when the best designed and most economical system is installed in the first place."

A complete copy of this report will be sent to interested plant managers who will write for it on their company letterhead.

THE KIRK & BLUM MFG. CO., 2855 Spring Grove Ave., Cincinnati, O.

I. E.
The Kirk & Blum Mfg. Co., Cincinnati, O.
Please send copy of your new catalog "Kirk & Blum Blower Systems."
Firm Name ....
Individual Name ....
Address ....
City .... State ....

Mail Coupon Today

KIRK & BLUM
Blower Systems
Collecting - Conveying - Ventilating

Chromalox Electric Heaters

FOR HEATING ISOLATED SHOPS AND OFFICES

crane cabs	drying rooms	elevators
laboratories	milk storage rooms	organ chambers
power houses	pump houses	scale rooms
storage rooms	sub-stations	watchman houses

and dozens of other places that are hard-to-heat!

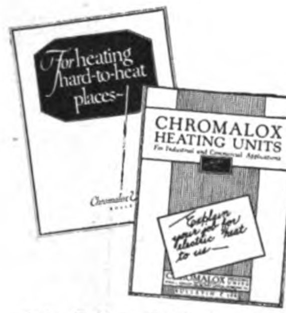
45 Sizes and Ratings. Three types. Horizontal, Vertical, Portable. 1000, 1500, 2000, 3000 watts. 110, 220, 250 volts.

Completely Assembled with 3 feet of cable, and 3-heat switch on standard conduit box. No assembly work!

Easily Installed! Simply mount on wall and connect to power line. Light and sturdy. Easily taken to the next job. Quicker than extending steam line!

Built to Last! The same type electric heaters fully approved for railway and street car service—will operate indefinitely on your heating jobs.

When writing for Bulletin C-108, send details about general construction of building, size of room or space to be heated, number of doors and windows, temperature required and voltage available. Then we can definitely tell you which size and type of electric heaters should be installed.



Left—Bulletin C-108 gives complete details about Chromalox Electric Heaters.

Right—Bulletin C-106—new edition—tells about standard Chromalox Strip, Space, Ring and Immersion Units.

Quick shipments from stock on electric heaters and heating units listed in both of these bulletins!

CHROMALOX

Mail with Your Letterhead!

[ ] Send Bulletin C-106 about Chromalox Units.
[ ] Send Bulletin C-108 about Chromalox Electric Heaters.

I.E.-12-26

We Need Electric Heat for—

Signed ____ Position ____

CHROMALOX HEATING UNITS

MANUFACTURED EXCLUSIVELY BY

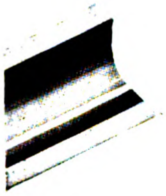
EDWIN L. WIEGAND CO., 422 FIRST AVENUE, PITTSBURGH, PA.

Sole Canadian Lincensees—The Canadian Chromalox Co., Ltd., 251 Queen Street East, Toronto, Ontario, Canada

The Railway Utility Company of Chicago is the sole distributor of Chromalox Strip Heaters for use in heating railroad and street cars in the United States and Canada

"Broadcasting"

Fittings In Giant New Broadcasting Battery Room



Every time you tune in on WTAM, the radio station of Willard Storage Battery Co., remember that Kondu Threadless Fittings help carry the power which brings you the music. Every one of the hundreds of conduit fittings in the great new battery room are Kondu.

Perhaps you will never face a conduit job as exacting or as intricate as this one, but whatever the job, Kondu Threadless Fittings will save a substantial percentage of the time for fitting installation. Fitting installation time usually represents the largest factor in a conduit job.

No threading is necessary—simply cut the conduit to size, ream, place in the end of the fitting, and screw down the locknut. A split, tapered bushing holds the conduit in a locked position, the ground rings in the bushing making complete conductivity.

Because threading is eliminated, it is unnecessary to rotate the conduit to lock it into the fitting, so multiple bends around obstructions may be made. Bends save fittings and the time required to install them.

Made of malleable iron—will bend, will not break—no scraping of enamel—ground rings insure perfect ground—no threads to rust—bead on bushing obviates danger of scraping insulation.

The coupon below will bring you a sample fitting, and you can see the quality and advantages yourself—send for it.

-BOX

PATENT OFFICE

IN CANADA

DUIT FITTING

Underwriters' Laboratories

Other sizes on test.

sion—Erie, Pennsylvania

Representatives

J. G. Pomeroy Co.,
Los Angeles, and
San Francisco, Cal.
C. R. Dederick,
Portland, Oregon, and
Seattle, Wash.
Fred E. Staible,
Denver, Colo., and
Salt Lake City, Utah.
W. A. Gibson,
Dallas, Tex.
E. E. Dawes,
Atlanta, Ga.

KONDU DIVISION
Erie Malleable Iron Co.
ERIE, PA.

☐ Sample Fitting

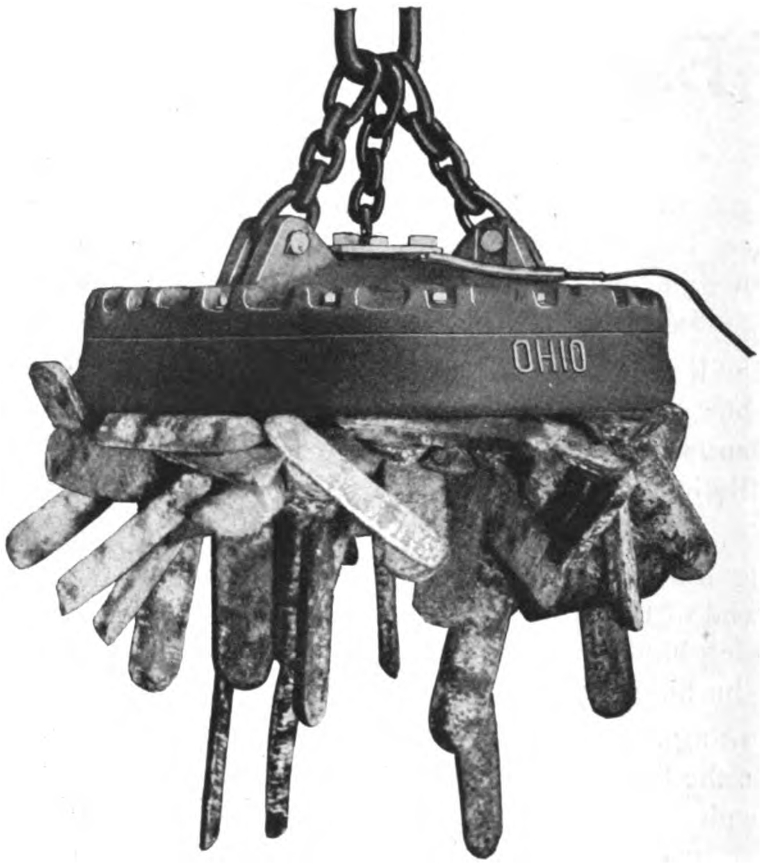
☐ Catalog

NAME...

COMPANY.....................................

ADDRESS.....................................

OHIO Lifting Magnets



65-in. Ohio Magnet and a heavy load.

Are lighest in dead weight yet they have maximum lifting capacity and lowest cost of upkeep due to their efficient design, all asbestos insulation and the absence of bolts on the bottom or working surface.

The OHIO ELECTRIC AND CONTROLLER CO.
5910 Maurice Ave., CLEVELAND, OHIO

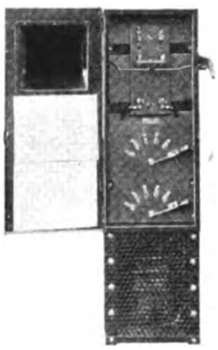
NEWARK TRANSFORMERS

This Transformer is double-wound, air cooled, single phase, 220 volt primary, 220/110 volt, 3-wire secondary.

This type is carried in stock in ½ to 10 kva. capacity.

For 440 or 550 volts primary, while not carried in stock, can be supplied promptly.

These Transformers can be used for either indoor or outdoor service.

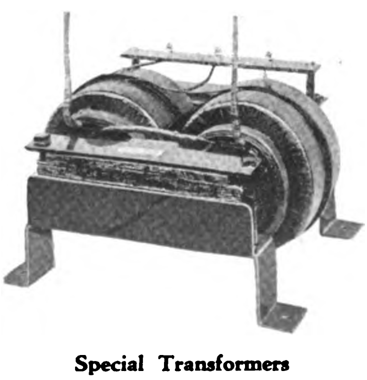


Electric Furnace Transformers

These Transformers are supplied for Electric Furnaces and other heating devices.

The Transformer is primary-tapped. The switchboard is supplied with radial switches for controlling the secondary voltage in 5% or smaller steps.

If required, the panel can be equipped with safety devices such that when the panel door is open, the primary circuit is disconnected, thus eliminating any danger when operating the control switches.



Special Transformers

We design and build transformers to your specifications or to suit your individual requirements.

New

A convenient, compact and portable— TESTING SET

Ideally suited to the needs of manufacturing companies and industrial plants where insulation, process and other semi-high potential tests are required.

Each set is equipped to handle the testing of such units and parts as may be specified by the user, and to deliver voltages up to 20,000 or higher. The standard equipment includes compression type rheostat, Weston voltmeter, pilot lamp, circuit breaker, double-pole, double-throw primary switch for 110 or 220 volts, single-pole, single-throw secondary switch and plugs for leads.

This set is also supplied with the necessary equipment for oil testing.

Descriptive circular on request.

Thirty years' experience back of each Transformer.

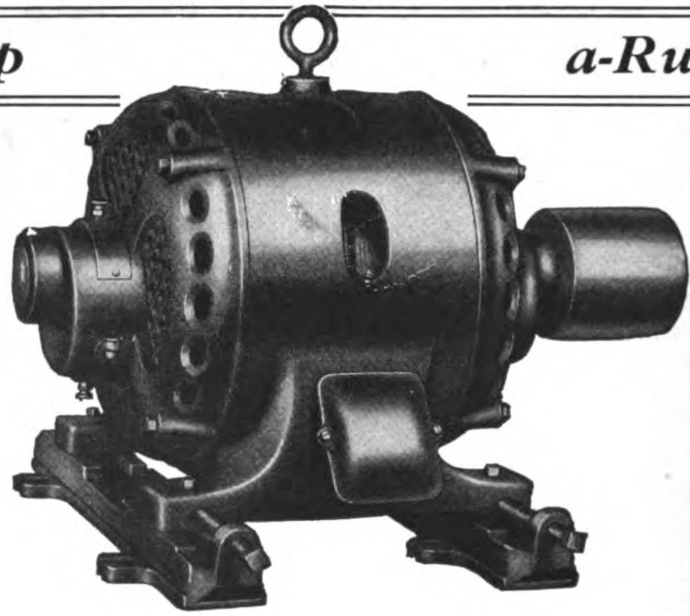
Our Engineering Department will gladly help solve your transformer problems.

NEWARK TRANSFORMER CO.
Newark, N. J.

General Sales Agents:

Porter & Ross, Inc.
30 Church St., New York City

"They Keep a-Running"



$7\frac{1}{2}$ Horse Power Century
Squirrel-cage Induction Polyphase Motor

Material Handling Equipment

"Keeps a-Running" With

Century

Century Squirrel-cage Induction Polyphase Motors are especially designed to meet the severe service requirements in all types of handling, elevating and conveying equipment. "They Keep a-Running" because of the following characteristics:

1. Armatures are practically indestructible. Copper conductor bars are brazed to channel-section end rings over an area equal to about six times the cross sectional area of the bars.
2. Thorough ventilation is assured by sheet steel fans mounted on each end of the armature, and—in the larger size motors—by the addition of grid ventilators as part of the armature structure.
3. Bearings are of cast phosphor bronze—the highest grade bearing material obtainable—accurately machined on all dimensions and provided with machine-cut figure-8 oil grooves.
4. Bearing housings are as nearly dust tight as it is possible to build them.
5. Shafts are of special shaft steel, ground true and then polished on all bearing surfaces.

Century Squirrel-cage Induction Polyphase Motors are built in all standard sizes from $\frac{1}{4}$ to 50 horse power.

Temperature rise not more than 40° Centigrade.

CENTURY ELECTRIC COMPANY

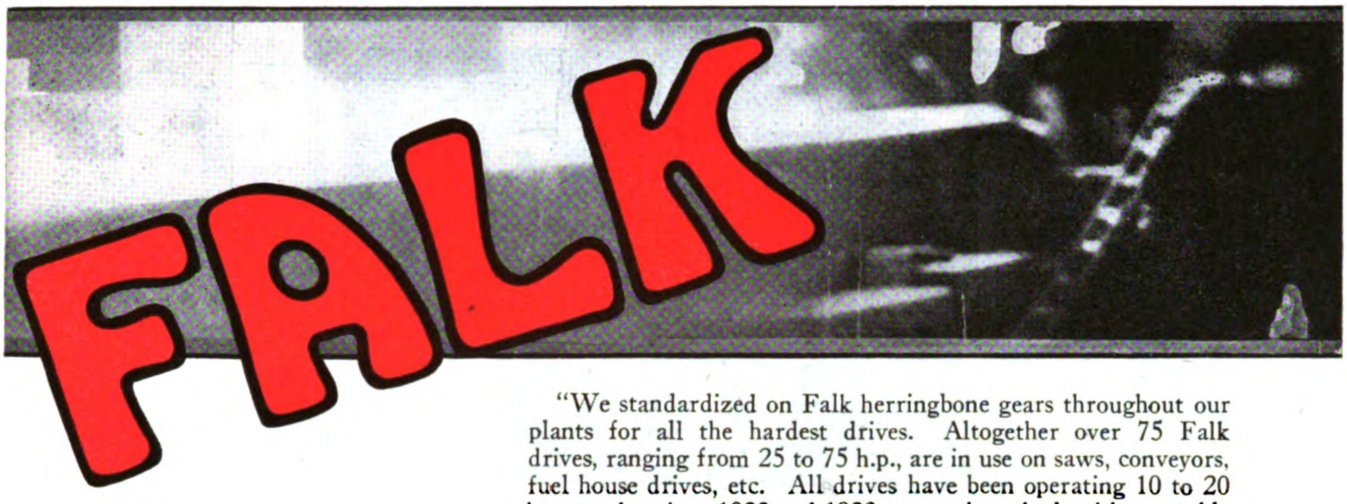
1806 Pine St. **St. Louis, Mo.**

For More Than 23 Years at St. Louis

$\frac{1}{4}$ to 50 H.P.

Century MOTORS

$\frac{1}{4}$ to 50 H.P.



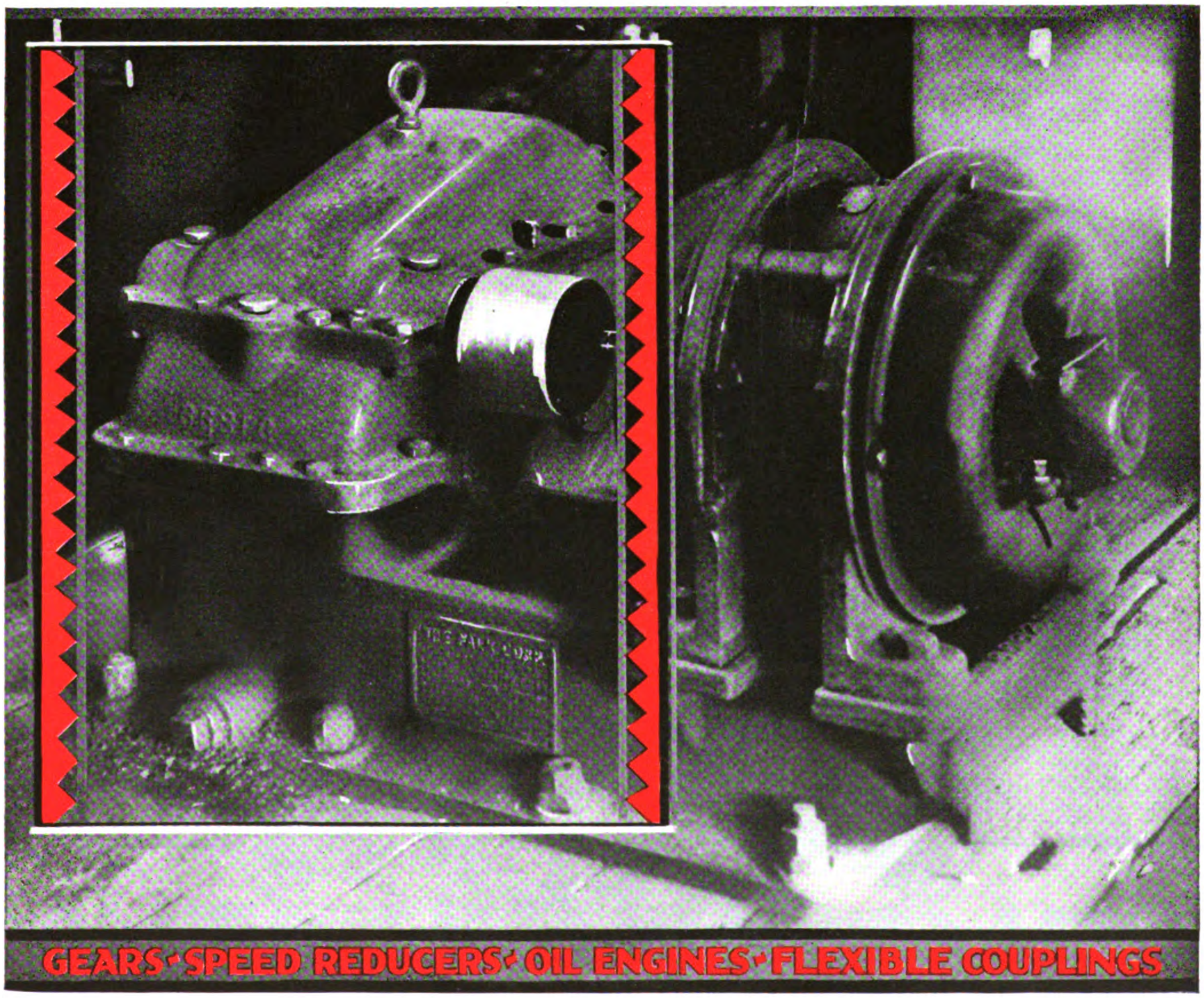
SPEED REDUCERS

"We standardized on Falk herringbone gears throughout our plants for all the hardest drives. Altogether over 75 Falk drives, ranging from 25 to 75 h.p., are in use on saws, conveyors, fuel house drives, etc. All drives have been operating 10 to 20 hours a day since 1922 and 1923, yet we have had neither trouble nor production delays due to any failure of the Falk gear units.

"Falk gears and Falk-Bibby couplings have been entirely satisfactory, and we would not think of doing without them. We are enthusiastic about all our Falk equipment because, once installed, it is so dependable that it can be forgotten."

J. W. Gates, Jr.
Crossett-Watzek-Gates, Chicago

The Falk Corp., Milwaukee, Wis.



Friction and Fuel

EVEN in the most modern steam engines, seldom more than one-fifth of the heat value of the fuel is converted into power. In other words, out of every five tons of fuel used, only one ton actually produces power that turns your machinery. A considerable loss occurs in converting water to steam in the boiler. Another large loss is caused by the discharge of exhaust steam, even when efficient condensers are used. In addition to these are the losses due to radiation of heat and due to friction.

An overall efficiency of twenty per cent presupposes practically perfect lubrication. With every increase in friction, whether in the driven machinery or in the steam engine itself, the percentage of power that is available for work is decreased. More fuel must be burned to overcome this friction in order to produce the same amount of available power.

To secure the largest possible percentage of work from the fuel you burn, it is necessary that your machinery—both engines and driven machinery—be lubricated with oils and greases that exactly suit their requirements and reduce friction to a minimum.

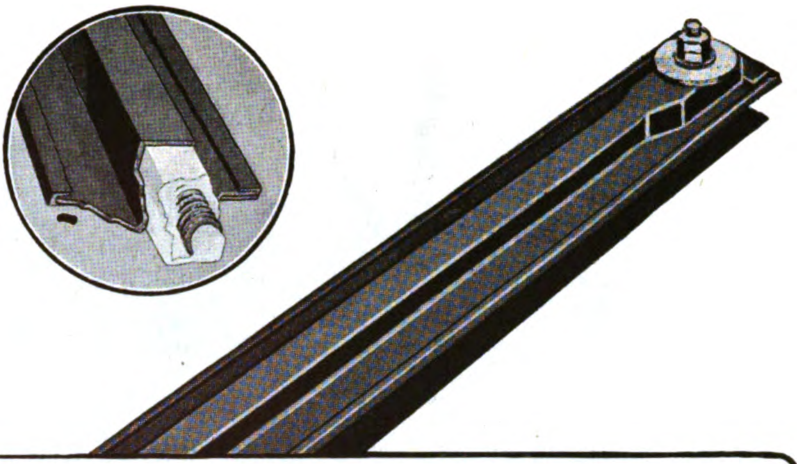
Standard Oils and Greases

are lubricants of the highest quality, and are made in grades to suit the requirements of all machinery now used in the industrial world.

Standardize on Standard Oils and Greases and you will save fuel, reduce depreciation and repair expense, and get more power.

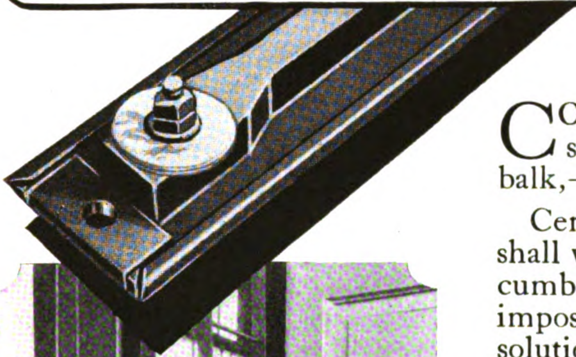
STANDARD OIL COMPANY
(INDIANA)
910 South Michigan Avenue Chicago, Illinois

Heating element of C-H Space Heater is embedded in a new refractory material. Heating efficiency is high—radiation is quick—insulation perfect. Very durable.



Why punish men or handicap equipment by unnecessary cold?

C-H



COLD men fumble, blunder,—often have their say about their boss. Cold machines eat power, balk,—break.

Certainly heating pays, but the question is, "How shall we do it?" Old heating methods are often too cumbersome to be practical. Sometimes they are impossible. Cutler-Hammer Space Heaters are the solution.

An electrical crane cab, for instance, or an elevator car can't be piped for steam heat. But wherever electricity is available these C-H "Heat Sticks" can be installed—in any necessary number.

Just 2 feet long, slim and compact—they are adaptable to all installation conditions. Can't be upset—they are safe.

Economical, too. Investment is negligible—efficiency is high. The heat is applied at the point needed and in the correct amount.

In all plants there are many heating jobs which these C-H Heat Sticks can do better—heating isolated rooms and buildings, maintaining proper temperatures of oils, chemicals and gases, applying heat at specific points in manufacturing processes.

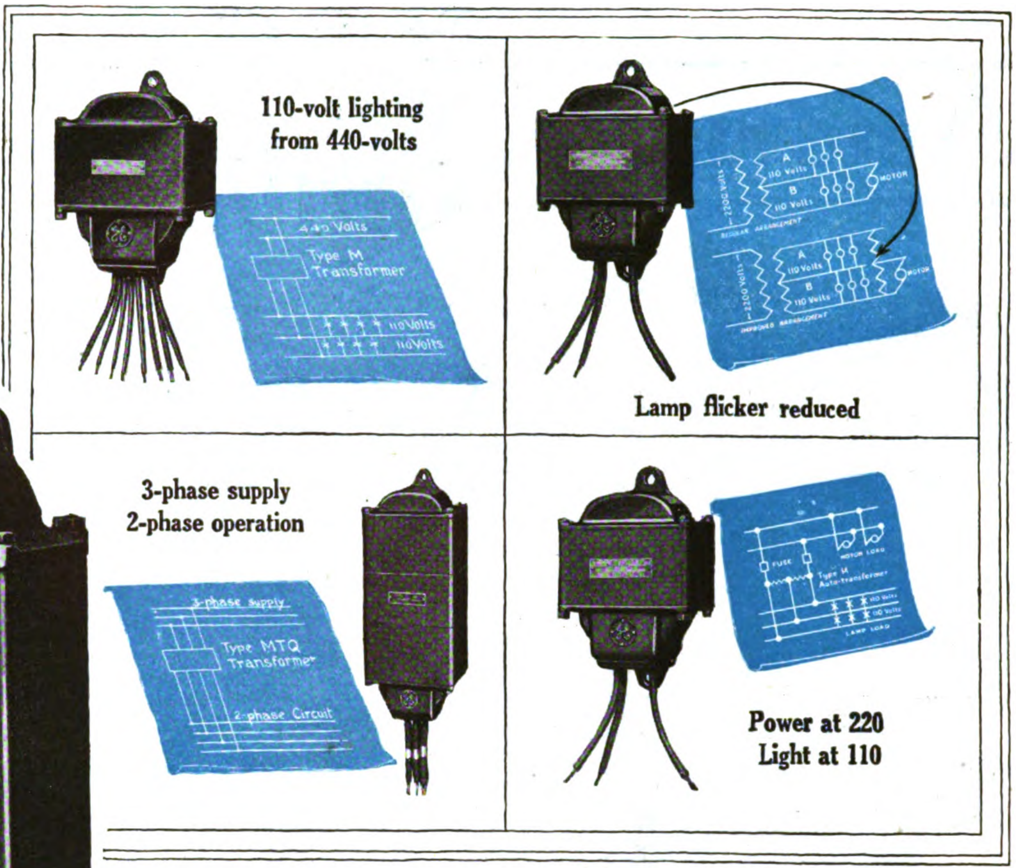
C-H Space Heaters in Cab on Coal Bridge, Milwaukee Western Fuel Co., Milwaukee, Wis.

Your electrical supply house has C-H Space Heaters. $2.00 each slightly less by box [10]. Order them today.

The "Dictionary of Uses" describes scores of typical installations of C-H Space Heaters. You can use many of them and they will suggest others. Write for a copy.

The CUTLER-HAMMER Mfg. Co.
Pioneer Manufacturers of Electrical Apparatus
1219 St. Paul Avenue
MILWAUKEE, WIS.

CUTLER-HAMMER



– and for *conduit* systems type M Transformers and Auto-transformers are built to fit *right into the line*

One of the desirable features of type-M's is the convenience with which these G-E Transformers can be used in either existing or new conduit wiring installations. For any of their various applications, the principal ones of which are illustrated above, they can be supplied so as to fit right into the line.

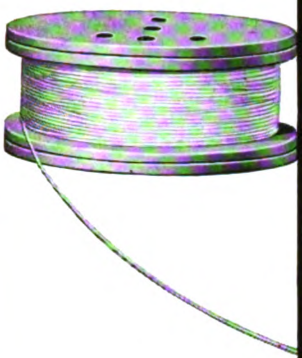
Carried in stock for either wiring system

To obtain complete information covering type-M Air-Cooled Transformers—ratings, dimensions, prices—a descriptive leaflet is available, through General Electric Offices. Ask for No. 65105.

17F-6

GENERAL ELECTRIC

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y., SALES OFFICES IN ALL PRINCIPAL CITIES



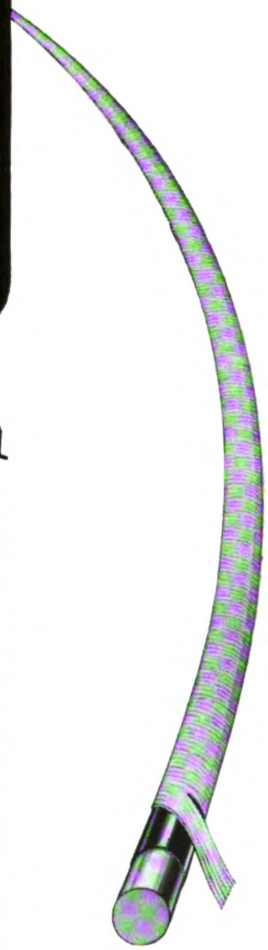
The electrical generation

WE LIVE in the electrical age. The most loved possession of the small boy is his electric train. The most faithful servants of the American woman are her electric appliances. The most economical power for man's great industrial plants is the electric power generated by central stations.

The key to the smooth, continuous functioning of every one is a strand of copper wire. Under the surface of a multitude of these toys, appliances, and huge generators lies **Rome Magnet Wire.**

For throughout industry you will find a growing preference, for Rome Magnet Wire, and for all Rome Wires. There is in these Rome products a desirable quality, brought by complete manufacture, supervision, and inspection in the Rome mills—from wire bar to finished copper wire.

Rome Service—ample stocks and competitive prices—are at your disposal, while an opportunity to quote on any of your wire requirements will always be welcome.



Single Cotton Enameled Magnet Wire

ROME WIRE COMPANY, ROME, N.Y.

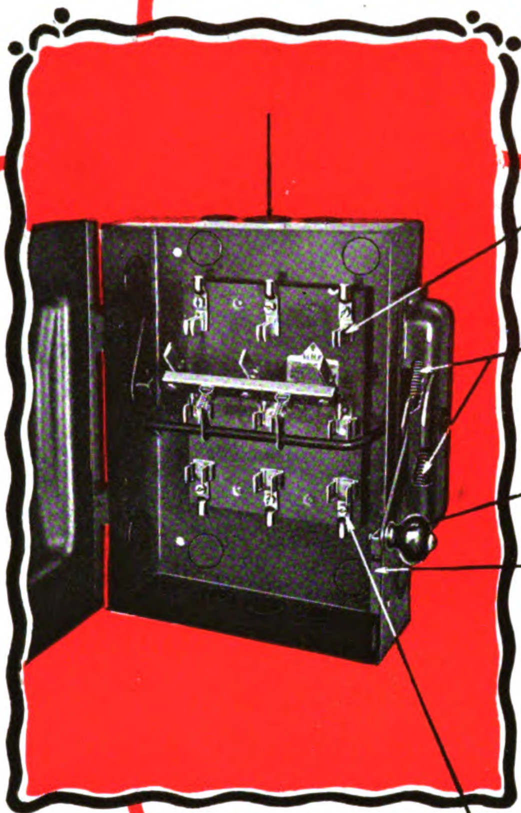
ROME WIRE

FROM WIRE BAR TO FINISHED COPPER WIRE


PAINT
this Way—
Use Vorcolite
flat white, specially compounded of the finest materials for gun application. Apply with the
Vortex Equipment
loaned without cost—a large capacity, rapid working paint gun, unequaled in covering big areas. Rely on
Your Handy Man
to do the work. With our paint and equipment he paints better and faster than a large squad of hand painters and needs scarcely any scaffolding.
One Application
suffices, as against two coats for any gloss paint. Flat white is better and more lasting. For additional data and estimate write to
THE VORTEX MANUFACTURING CO.
1986 West 77th Street Cleveland, Ohio
VORCOLITE
INSIDE
GUN - APPLIED
WHITE
V 23

Every Industrial Plant has use for this TV Safety Switch

Concentric Knockouts



Type A contact. The contact finger is of spring copper, sweated and pinned into solid terminal block.

2 heavy springs which operate switch.

Safety handle.

Interlocking device prevents access to fuse until they are dead.

Fuse clip terminals

Type "A" heavy duty TV Safety Switch

Made in all capacities. For general industrial use.

There are many safety switches, but this Type "A" heavy duty TV Safety Switch is built, not on a price basis, but rather to give the industrial plant a switch that will meet every requirement of service, for all time.

It is very ruggedly built and made to stand up under full load or overload conditions without breakdown. It will last indefinitely, and will continually guard the safety of employees. The installation of these switches is good insurance. A few of the important features are pointed out above.

Our representative will give you more. A line to us will bring him.

We make Safety Switches for every Industrial purpose.

Type "A" closed.

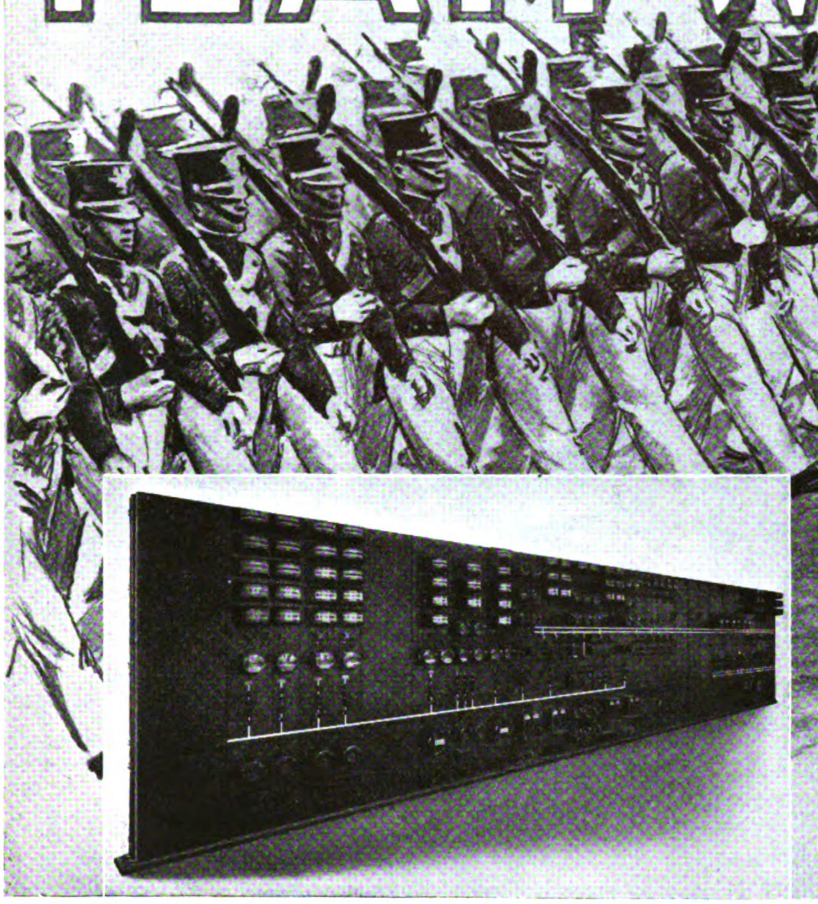
Fool proof and good insurance.

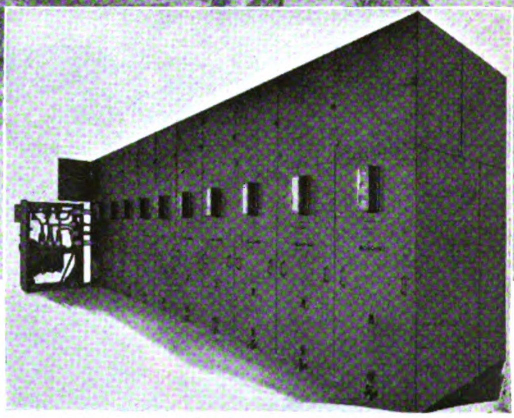
TRUMBULL-VANDERPOEL ELECTRIC MFG. CO.
BANTAM, CONN.

Complete stocks are carried in eleven distributing points throughout the United States

TV SAFETY SWITCHES

TEAM WORK





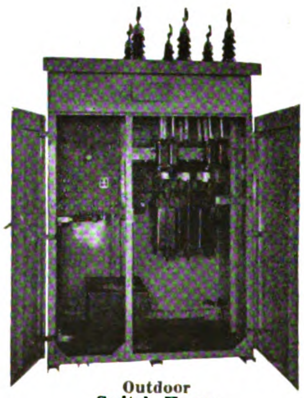
Safety Enclosed Switchboard, Removable Truck Type

Left!—Left!—with machine-like precision every foot and arm swings forward as one. Imagine the effect that one man out of step would have on that perfect line of march! But it never happens. ***Each individual does his part exactly right.***

The same sort of teamwork from engineer to inspector must be developed to build switchboards that are one hundred per cent *right*. The Condit organization possesses the facilities to design and build the type and size of switchboards that will meet your exact requirements and the teamwork to make them as near perfection as humanly possible.

CONDIT ELECTRICAL MFG. CORPORATION
Manufacturers of Electrical Protective Devices
Boston, Mass.

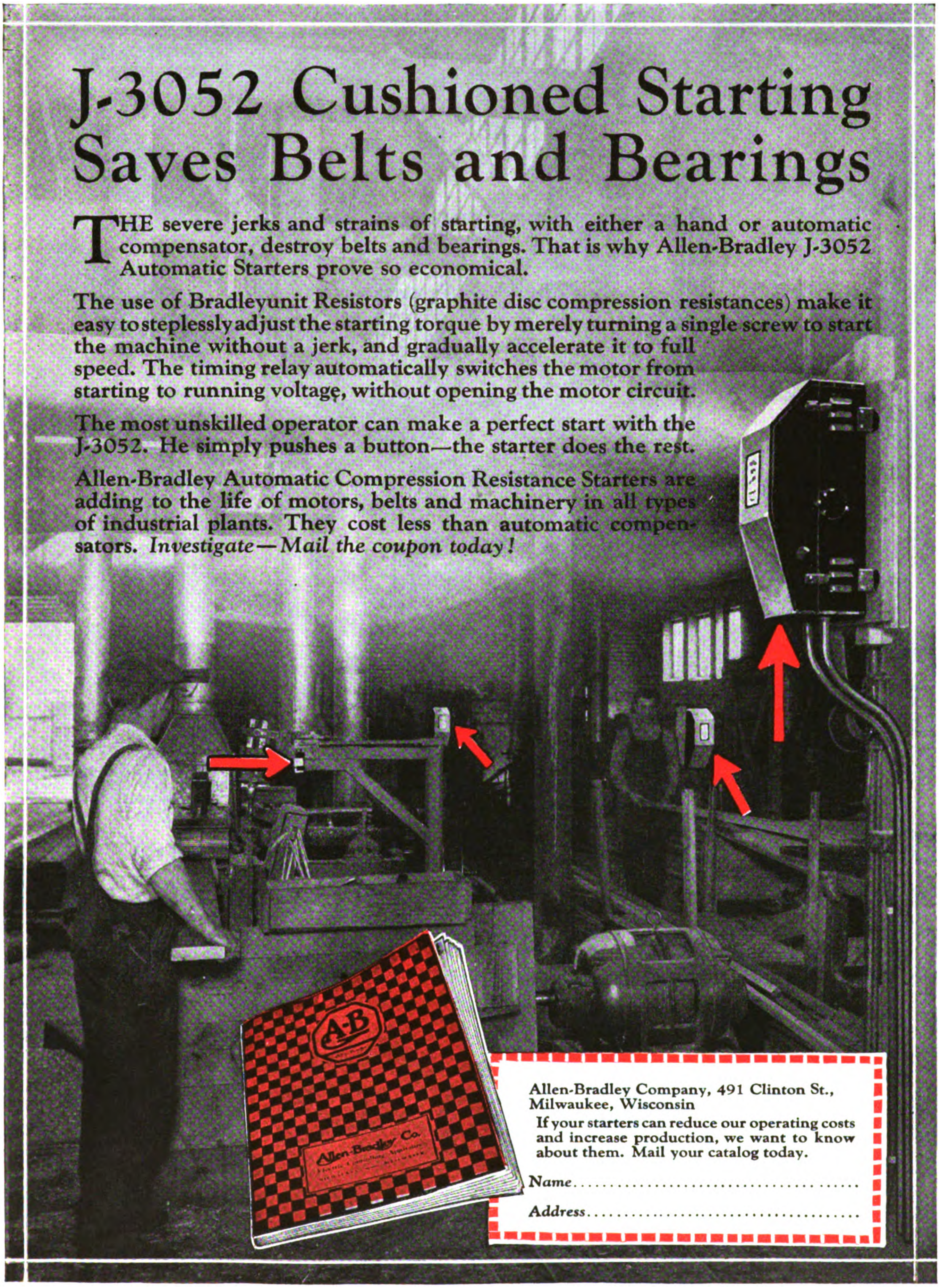
Northern Electric Company
LIMITED
Sole Distributor for the Dominion of Canada



Outdoor Switch House

For safety enclosed switchboards — removable truck type — benchboards, electrical and manual controlled switchboards, get in touch with Condit.

CONDIT


J-3052 Cushioned Starting Saves Belts and Bearings
THE severe jerks and strains of starting, with either a hand or automatic compensator, destroy belts and bearings. That is why Allen-Bradley J-3052 Automatic Starters prove so economical.
The use of Bradleyunit Resistors (graphite disc compression resistances) make it easy to steplessly adjust the starting torque by merely turning a single screw to start the machine without a jerk, and gradually accelerate it to full speed. The timing relay automatically switches the motor from starting to running voltage, without opening the motor circuit.
The most unskilled operator can make a perfect start with the J-3052. He simply pushes a button—the starter does the rest.
Allen-Bradley Automatic Compression Resistance Starters are adding to the life of motors, belts and machinery in all types of industrial plants. They cost less than automatic compensators. *Investigate—Mail the coupon today!*
A-B
Allen-Bradley Co.
Allen-Bradley Company, 491 Clinton St., Milwaukee, Wisconsin
If your starters can reduce our operating costs and increase production, we want to know about them. Mail your catalog today.
Name.....................................
Address..................................

HERRINGBONE

Speed reducers by D. O. James Manufacturing Company—a product backed by the same reputation that has so firmly established James Spur Gear and Worm Speed Reducers with industry.

Made under a special process that allows for a continuous "V" shaped tooth with a 20° pressure and a 30° helix angle, in all ratios from 2 to 1, to 150 to 1, and from 2 to 200 H. P.

The many features of longer life, less power consumption, elimination of vibration, greater reduction in a given space, speeds and heavy duties makes these units ideal for the severe service for which they are intended.

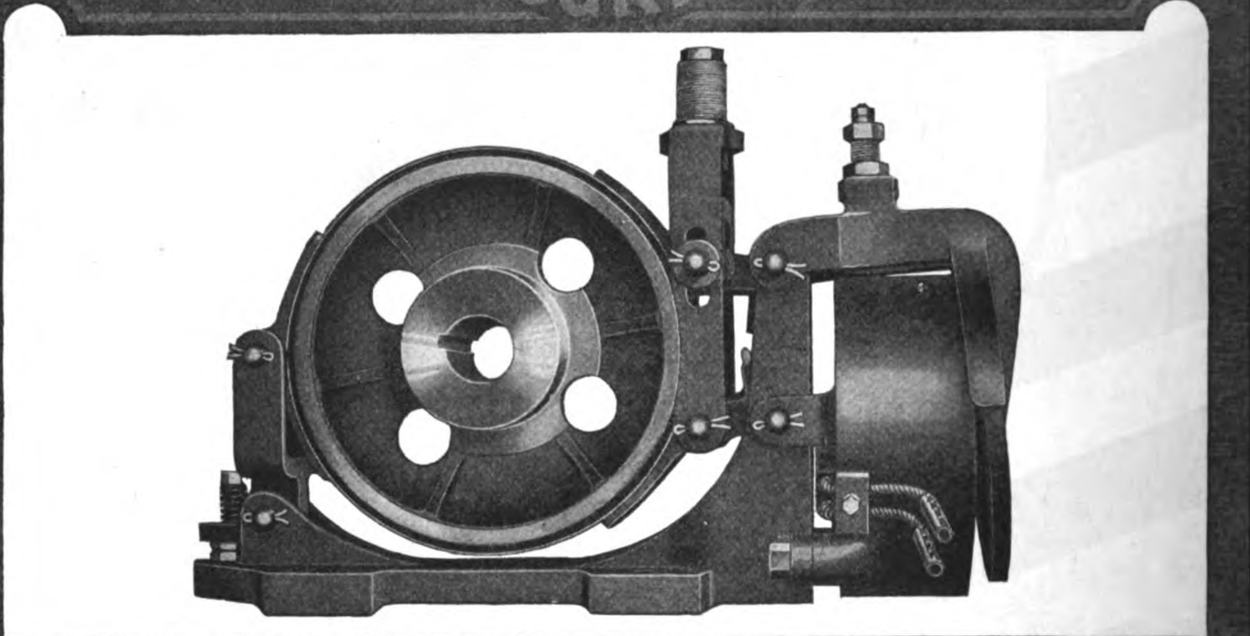
Let us tell you more about James Continuous Tooth Herringbone Speed Reducers.

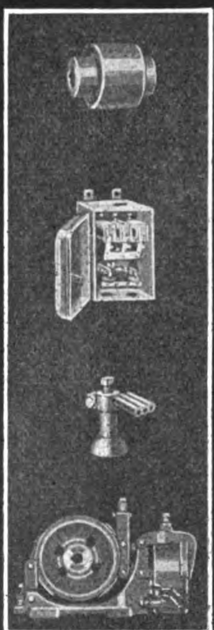
D.O.JAMES

1120 W. MONROE STREET
CHICAGO, ILL.

THE "3C" BRAKE

PROGRESS





The Clark "3C" Brake is of the split-band type. It combines band-brake efficiency with shoe-brake characteristics.

Is equally effective in either direction of rotation. Has shown exceptionally low maintenance cost.

This brake is now in use in over twenty-five different plants and has been given unqualified approval in every case.

For Further Information Write for Bulletins 102 and 102-A

THE CLARK CONTROLLER CO.

CHICAGO	DETROIT	NEW YORK	1146 E. 152ND ST.	PHILADELPHIA	PITTSBURGH	BIRMINGHAM
53 W. JACKSON BLVD.	FRANCIS PALMS BLDG.	WOOLWORTH BLDG.	CLEVELAND, OHIO	ATLANTIC BLDG.	UNION TRUST BLDG.	BROWN-MARX BLDG.
R.E. BOCK	L.H. ALLISON CO.	K.I. CLISBY		O.L. HOLCOMBE	A.B. HOLCOMB	C.P. LEIBOLD
DIST. MANAGER	DIST. MANAGER	DIST. MANAGER		DIST. MANAGER	DIST. MANAGER	DIST. MANAGER


BUSS FUSES
TRADE BussFuses ELECTRICITY'S SAFETY VALVE MARK REG. U.S. PAT. OFF.
APPROVED IN ALL TYPES AND SIZES
Buss Fuses Keep Century "a-Running"
The makers of the renowned Century Motors find that BUSS Renewable Fuses meet the most exacting tests of service to give them complete electrical protection.
The illustration is an interesting view of one of their electric furnace rooms. The circuit controlling these furnaces as well as the multiplicity of other circuits throughout their plants are being protected by BUSS Renewable Fuses.
The testimony of thousands of such satisfied users and the simple correctness of BUSS design are in themselves convincing proof of BUSS superiority—but only the actual test of service will show you the true saving in time, labor and money that an installation of BUSS renewable Fuses will give you. Specify them on your next requisition.
A sample is yours for the asking.
BUSSMANN MFG. CO. · · ST. LOUIS MO.
4 parts and the Link
That's All!

BABBITT —

An Important Renewal Item

THE bearing is the point of greatest wear in a motor. Re-babbitt worn bearings in Westinghouse industrial motors with Westinghouse Alloy No. 25—just as you replace other worn parts with Westinghouse renewal parts. Then, you keep the bearings up to the high standard set by the rest of the motor; you maintain the *balance* (mechanical and electrical) characteristic of all Westinghouse motors.

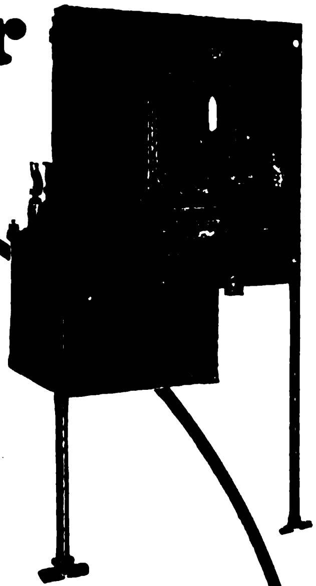
Westinghouse Electric & Manufacturing Company
East Pittsburgh Pennsylvania
Sales Offices in All Principal Cities of the United States and Foreign Countries

Westinghouse

X91001

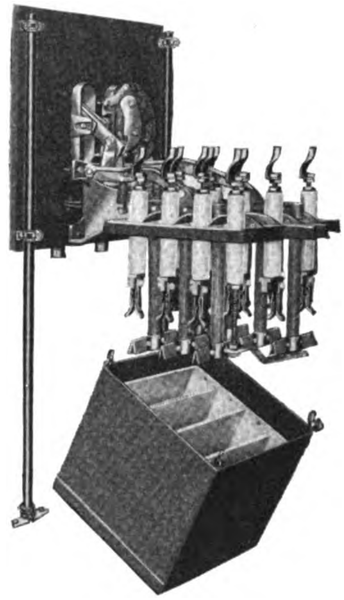
Alloy No. 25
(Lead Base Babbitt)

A New Motor-Starting Oil Circuit Breaker



Type MF

Capacity 1,000 hp. at 2,500 volts. Interrupting capacities 1,000 to 7,200 amperes at rated voltages.

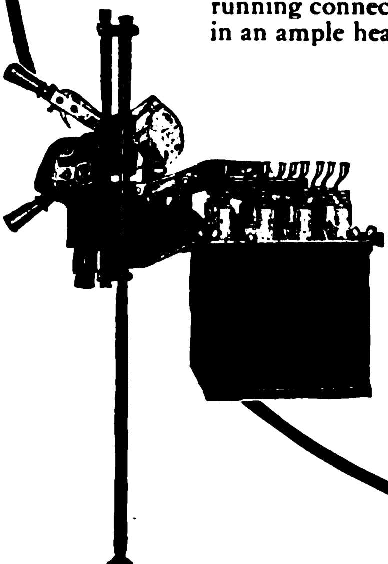


MANUALLY operated, for starting, in connection with auto-transformers, three-phase induction motors and self-starting synchronous motors.

A careless, or ignorant operator cannot throw the wrong switch handle when starting the motor. A mechanical sequence-starting interlock prevents throwing the breaker to the running position without first going through the starting position.

Some other distinctive features are:

One tank contains all starting and running connections, immersed in an ample head of oil.



A highly efficient form of wedge and finger-type contacts is used. The fingers are flexibly mounted, therefore self-aligning, exerting high contact pressure by means of a separate stiff-steel spring.

The safety of the apparatus is assured by inverse time limit, automatic overload current-transformer trip coils, and by under-voltage release mechanism, which opens the breaker when the voltage fails.

Send for Leaflet 20292; it gives a full description of the MF breaker.

Westinghouse Electric & Manufacturing Company
East Pittsburgh Pennsylvania
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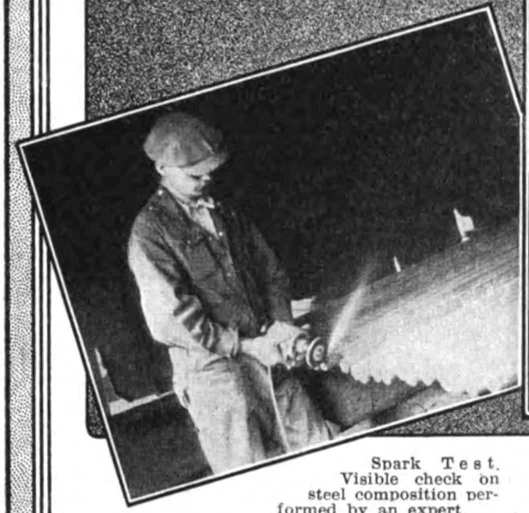
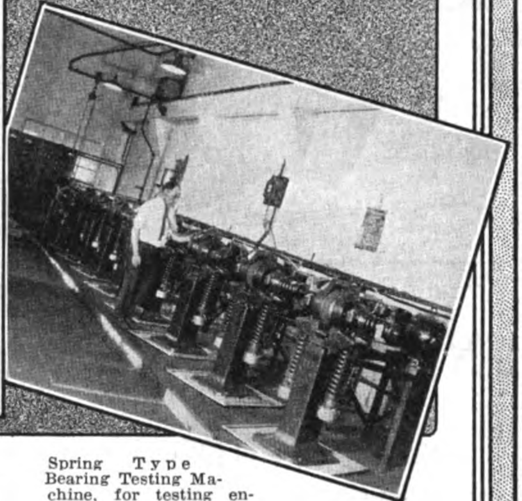
Westinghouse

X90164



Spark Test. Visible check on steel composition performed by an expert.

Projecting lantern for physical research and examination of specimens.



Spring Type Bearing Testing Machine, for testing endurance under load.

THE enduring quality and precision of New Departure Ball Bearings is assured by the most exacting laboratorial checks and tests known to metallurgical science.

The production of New Departure Ball Bearings has doubled within the last five years. The endurance life of New Departure Ball Bearings has increased 600 per cent. in the same length of time.

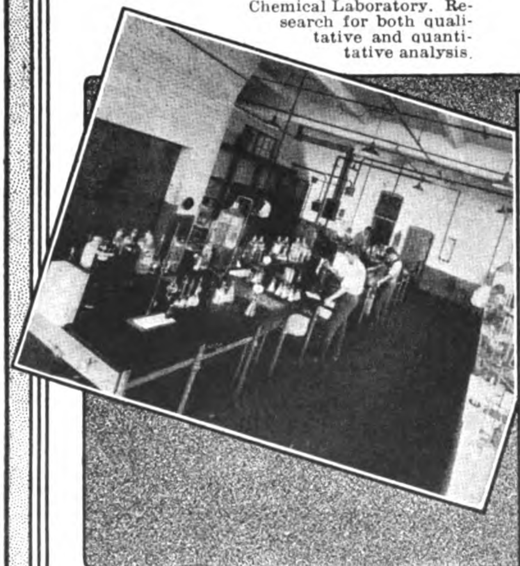
Our staff of engineers is at your disposal for the solution of your bearing problems. A request puts you under no obligation.

New Departure
Quality
Ball Bearings

Engineering data in the form of bulletins will be furnished you together with a convenient binder provided you can make advantageous use of them.

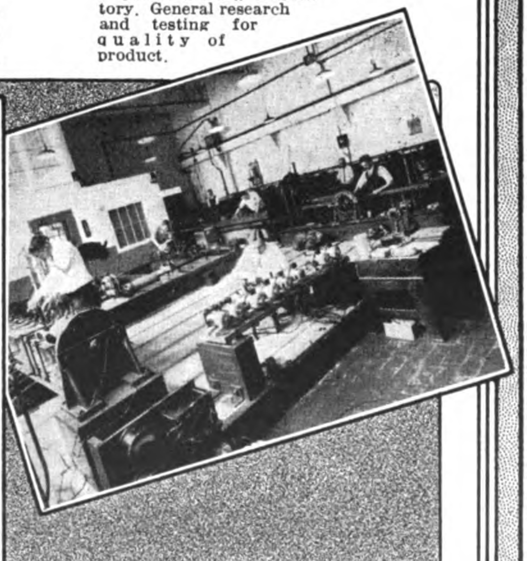
THE NEW DEPARTURE MANUFACTURING COMPANY
Chicago — *Bristol, Connecticut* — Detroit

Chemical Laboratory. Research for both qualitative and quantitative analysis.



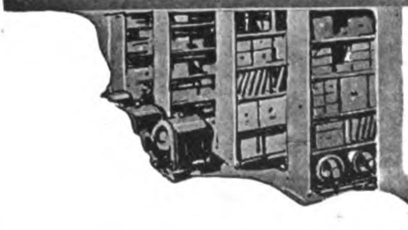
Amsler Precision Compression Machine. Capable of measuring resistance to crushing forces of from 150 pounds to 200,000 pounds.

Physical Testing Laboratory. General research and testing for quality of product.



506

MAINTENANCE SERVICE, REPAIR PARTS, TOOLS AND SUPPLIES

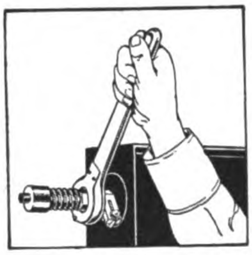


In the maintenance departments of every industrial works and in every commercial electrical repair shop the range of the work that *can be done* and the dollar-savings that *are possible* depend on
(1) The ability and experience of the maintenance man.
(2) Adequate hand and bench tools and shop equipment.
(3) A well-balanced stock of spare units, parts, wiring supplies and raw material used in repair work.
Here then is a directory to the needs of the maintenance man under items (2) and (3) that he can use when he must have things in a hurry on an emergency job and when ordering for stock to meet his regular maintenance requirements.

GUARANTEED *To Save Money!*

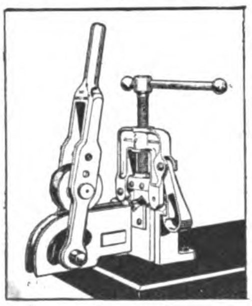
ALL JIFFY TOOLS

are guaranteed to prove satisfactory or your money refunded promptly. Order any tool on approval.



"JIFFY" Adjustable CUTTER

Cuts holes in steel boxes, switchboard panels, etc., any diameter ¾ in. to 6 in., quickly, easily and inexpensively. A time- and labor-saver necessary in every electrical department.



"JIFFY" PIPE BENDER VISE

Makes perfect bends, quickly, easily and accurately without kinking, flattening or splitting the pipe. Bends either downwards or sidewise. Eliminates in many cases costly fittings. Insures absolute accuracy.

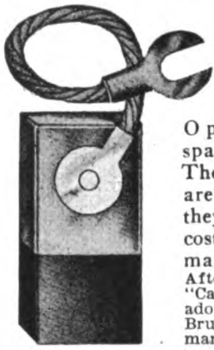
Bends either ½- or ¾-in. conduit. Strongly built, it will serve also as an ordinary pipe vise for pipe up to 2 in. Pays for itself in Time and Money Saved. A Real Labor Saver.

Order It on Approval.

PAUL W. KOCH & CO.
33 S. Wells St., CHICAGO

Write for Complete Catalog

"CARENCO"



BRUSHES

Operate without spark or noise. These characteristics are so noticeable, they eliminate all costly identification marks.

After thorough tests "Carenco" Brushes are adopted as a Standard Brush equipment by many of the biggest users.

Let us send you our new catalog and data sheet. Prove the value of "Carenco" Brushes to yourself!

CARBON-ENGINEERING-CO.
Milwaukee, Wis.

Maintenance and Repair

will get special attention in

February, 1927, *issue*

LOCK YOUR LAMPS

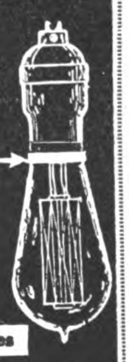
WITH ONLY TWO PARTS

REN-LOCKS

FIT STANDARD BULBS AND SOCKETS

A COILED SPRING and

A GROOVED RING



We Sell Direct-Write for Samples

Ren Mfg. Co. 971 Main St., Winchester, Mass.

FIGURE IT OUT

Flower Brush Holders are designed and built by brush holder specialists to meet the needs of a specific job. They're simple—they're rugged — and they're made only from the finest virgin metals. Naturally they last longer, are more reliable, and parctically eliminate "flashover" risks.

Quotations gladly given on any type

FLOWER

BRUSH HOLDERS

D. B. FLOWER
1217 Spring Garden Street, Philadelphia

Manufacturers of Brush Holders for Motors, Rotary Converters, Generators and Dynamos

NO Spark Carbon Brushes

are Self Lubricating They last longer and serve better than ordinary Brushes. Give them just one trial.

Calebaugh Self-Lubricating Carbon Co.
1503 Columbus Ave.
Philadelphia, Pa.

be Balanced

—so must MOTORS

MEAT, mashed potatoes and white bread, with cakes, cheese and coffee:—sounds like a pretty good layout, doesn't it?

A submarine crew tried such a diet and was forced into port after eight month's cruising with some of their men at the point of death.

Similarly, unbalanced design—improper proportioning of the factors listed here—may hurry a motor into the service shop. A motor's life and service depend on the skill and experience with which the manufacturer balances all the factors to one another and to the work for which the motor is designed

For instance, efficiency: Beyond a certain point in the design of every motor, added efficiency can be obtained only at too great sacrifice of other qualities. Compare a Westinghouse alternating-current motor of 89 per cent efficiency, with a rival motor rated at 90 per cent. On the face of things this comparison is unfavorable to Westinghouse. Look at power factor, however, and you find that to gain 1 per cent more efficiency the rival motor has reduced power factor to 85 per cent, while that of Westinghouse is 88 per cent. Thus in terms of *power bills* the motor with a closer balance between power factor and efficiency is by far the better motor.

A motor is balanced when the following factors are properly proportioned to one another and to the job which the motor has to do:

Electrical	Mechanical
1. Temperature	8. Air gap
2. Torques	9. Bearings
3. Efficiency	10. Shaft
4. Power Factor (in alternating-current motors).	11. Steel
5. Speed characteristics	12. Assembly
6. Insulation	13. Rotating smoothness
7. Commutation (in direct-current motors)	

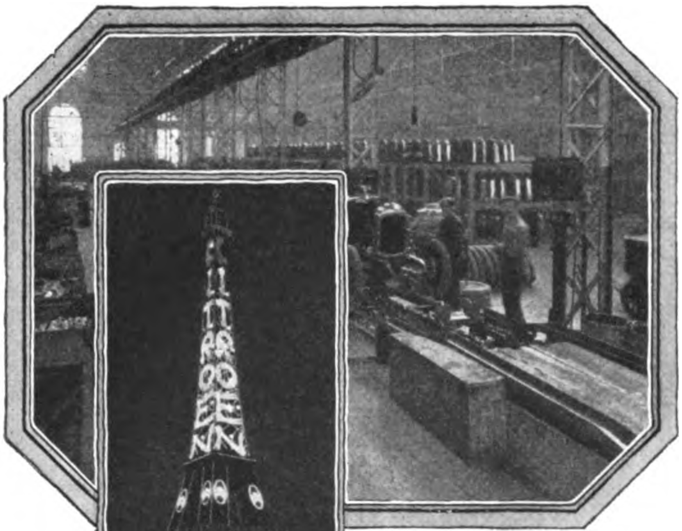
To get true value in a motor look at *all* these factors, not merely at one or two.

In Westinghouse Motors each factor has been weighted after years of experience extending into every industry and dating from the dawn of the motorizing idea. A truly balanced design for every purpose is the result.

Westinghouse Electric & Manufacturing Company
East Pittsburgh Pennsylvania
Sales Offices in All Principal Cities of the United States and Foreign Countries

X88782

are Balanced



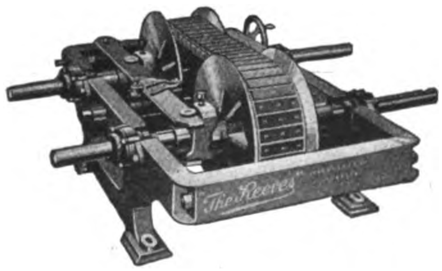
Above: One of Citroen's conveyors that is REEVES-controlled.
Left: The Eiffel Tower in Paris—the World's highest electric signboard.

André Citroën Knows the Value of Speed Flexibility!

ANDRÉ Citroën has modeled after the best "Detroit" methods in the production of his automobile. His plants in France, Italy, England and Belgium have a yearly capacity of 235,000 cars—the greatest production schedule of any European manufacturer.

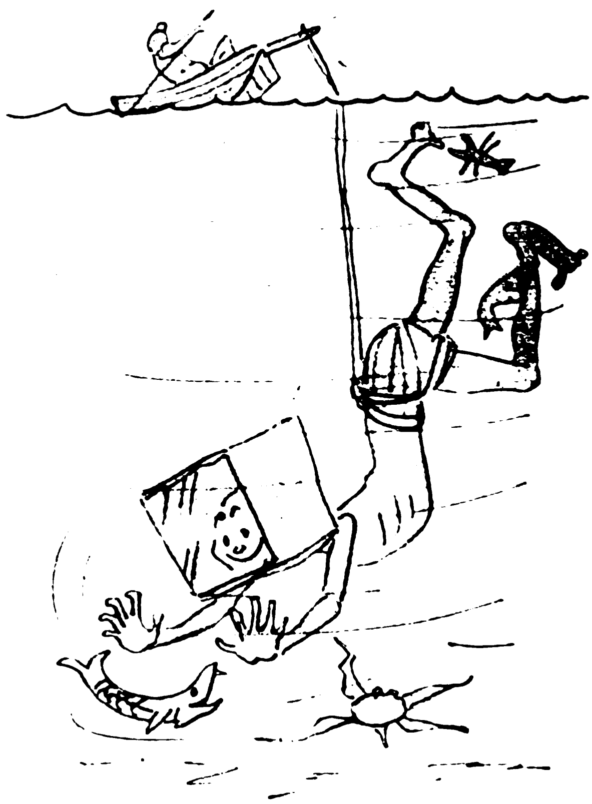
Citroën regulates the speed of his conveyors with the device used by Buick, Cadillac, Hudson, Chrysler, Chevrolet, Packard and other leading American automobile manufacturers. He uses 110 Reeves Transmissions. In *your* industry, on *your* production machines and conveyors, there is a very definite need for speed flexibility. Send for Catalog E-66 for complete information.

REEVES PULLEY COMPANY
Established 1887
Columbus, Indiana



THE REEVES Transmission represents the *only* method which gives you *complete* speed flexibility. It does not give just steps in speed—but *any* speed between fastest and slowest, even to the smallest fraction of a revolution. It is simple, inexpensive, compact. Easy to install and simple to operate. You can get *any* speed at *any* time on *any* machine that is REEVES-equipped.

REEVES
Variable Speed Transmission



NITCHI JATHA

The nitchi jatha is the native deep diver.

He constructs for himself an ingenious telescope to spy out the wonders of the ocean bed.

It's simply a large tin can with a sheet of glass on one side.

It works—so he's satisfied.

Now let us change the scene to a plant equipped with misfit carbon brushes.

Enter the Morganite engineer to help the operators improve commutation.

He's told through the din of the chattering brushes that they work—so they're satisfied.

The answer to which is a long story which you can get by calling in one of the representatives below:

Morganite Brush Co. Inc

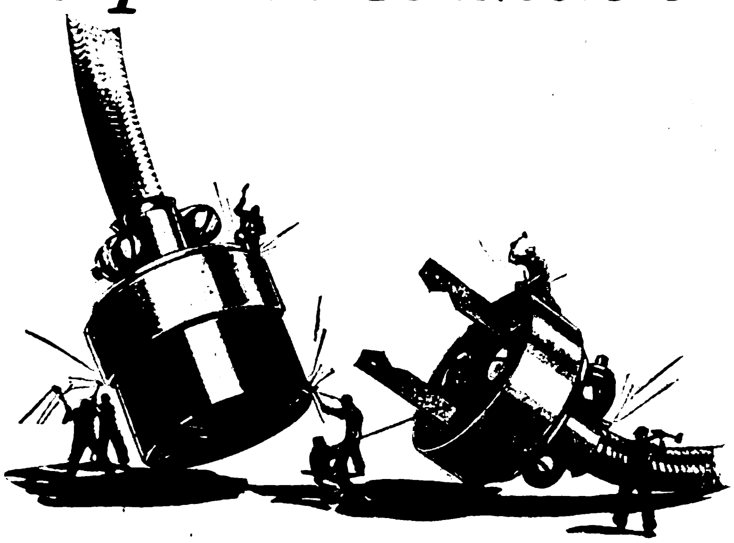
Main Office and Factory
519 West 38th St., New York

DISTRICT ENGINEERS AND AGENTS

Pittsburgh, Electrical Engineering & Mfg. Co., 909 Penn Ave.
Cincinnati, Electrical Engineering & Mfg. Co., 607 Mercantile Library Building.
Cleveland, Electrical Engineering & Mfg. Co., 422 Union Building.
Baltimore, O. T. Hall, Sales Engineer, 437-A Equitable Building.
Revere, Mass., J. F. Drummey, 75 Pleasant Street.
Los Angeles, Special Service Sales Co., 502 Delta Building.
San Francisco, Special Service Sales Co., 222 Underwood Building, 545 Market Street.
Toronto, Can., Railway & Power Engineering Corp., Ltd., 101 Eastern Ave.
Montreal, Can., Railway & Power Engineering Corp., Ltd., 326 Craig St., West.
Winnipeg, Can., Railway & Power Engineering Corp., Ltd., P. O. Box 325.

Cord Grip

Caps and Connectors



TOUGH—from head to toe!

Hard Knocks—gruelling shop service —is what these devices thrive on

The connector bodies of these Hubbell "Cord Grip" Devices are made of strong black composition. They withstand the hardest kind of service and abuse.

Caps of composition are *completely* armored by a heavy, "all-over" shield of steel—galvanized to prevent corrosion. The contact blades, because they are made of heavy gauge metal and are firmly anchored, stay in alignment and don't get "wobbly."

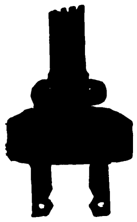
Ask your electrical supply house to show you samples.

The New "Twist-Lock" Locking Connector

See this new Hubbell Connector, illustrated at the right—Catalog No. 7100. Plug the cap into this connector—turn—and the two are securely *locked* together. A twist of the wrist—and they are unlocked.

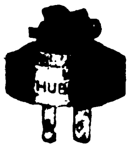
The locking feature of this Hubbell Connector provides an extra and very effective safeguard against accidental disconnection. It is of distinct advantage in industrial plants and other places, particularly where service is unusually severe or where connectors are subjected to considerable vibration.

HARVEY HUBBELL INC
ELECTRICAL SPECIALTIES
BRIDGEPORT, CONNECTICUT, U.S.A.
NEW YORK, N.Y. CHICAGO, ILL.

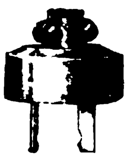


No. 7056
2-wire
Tandem Blades
10 Amp., 250 V.

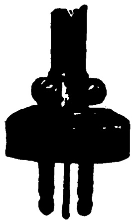
No. 7057
2-wire
Parallel Blades
10 Amp., 250 V.



No. 7059
2-wire
Parallel Blades
Polarized
10 Amp., 250 V.

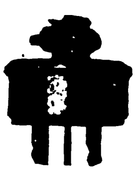


No. 7092
2-wire
Polarized
10 Amp., 250 V.

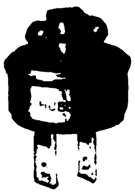


No. 7055
3-wire
Polarized
10 Amp. 250 V

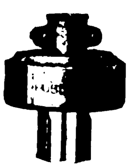
No. 7058
2-wire
Polarized
20 Amp., 250 V.



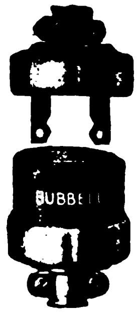
No. 7089
3-wire
Polarized
20 Amp., 250 V.



No. 7127
2-wire
Polarized
30 Amp., 250 V.

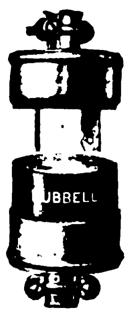


No. 7113
3-wire
Polarized
30 Amp., 250 V.



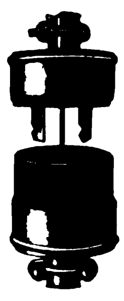
No. 7083
2-wire
Double Te-slots
10 Amp., 250 V.

No. 7090
2-wire
Polarized
10 Amp., 250 V.

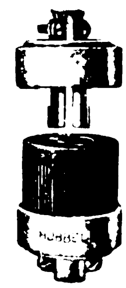


No 7085
2-wire
Polarized
20 Amp., 250 V.

No. 7081
3-wire
Polarized
10 Amp., 250 V.

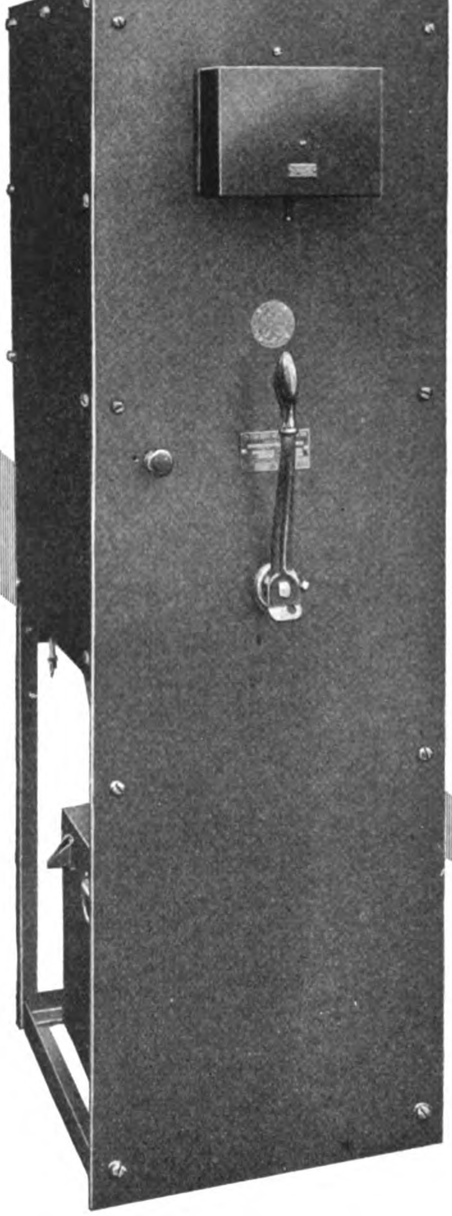


No. 7087
3-wire
Polarized
20 Amp., 250 V.



No. 7100
2-wire
"Twist-Lock,"
Locking Type,
10 Amp., 250 V.

And ---
in the field of AC Manual Control
G-E offers



CR1034, 2200 V. starting compensator for two- and three-phase induction motors. Dead-front, panel type; high interrupting capacity; time delay undervoltage protection; thermal overload protection.

CR1034 starting compensator (550 V. and less) for two- and three-phase induction motors. Undervoltage protection (with time delay if desired); thermal overload protection.

General Electric builds control of exceptional design, construction, and performance for every motor application. Write for the Industrial Control Catalog, GEA-257. It contains the complete story together with much valuable information on correct control applications.

GENERAL

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

ROCKBESTOS
— the asbestos covered wire

For General and Unusual Service

Rockbestos Magnet Wire is usually found in all types of motors that are subjected to extreme heat conditions or to overloads that would break down ordinary magnet wire.

Rockbestos insulation cannot be improved and has long been the standard for asbestos covered wire and cable. The motor here illustrated is one of the Crocker-Wheeler heavy duty type, operating a Bloom Shear. Overloading or unusual heat conditions will not effect the operation of the motor, because of the protection afforded by Rockbestos insulation. This is only one instance of the daily service Rockbestos magnet and other wires are giving.

How about your spare motors? Are you rewinding them with Rockbestos?

It's good insurance against shut down.

ROCKBESTOS Research and Advisory Service

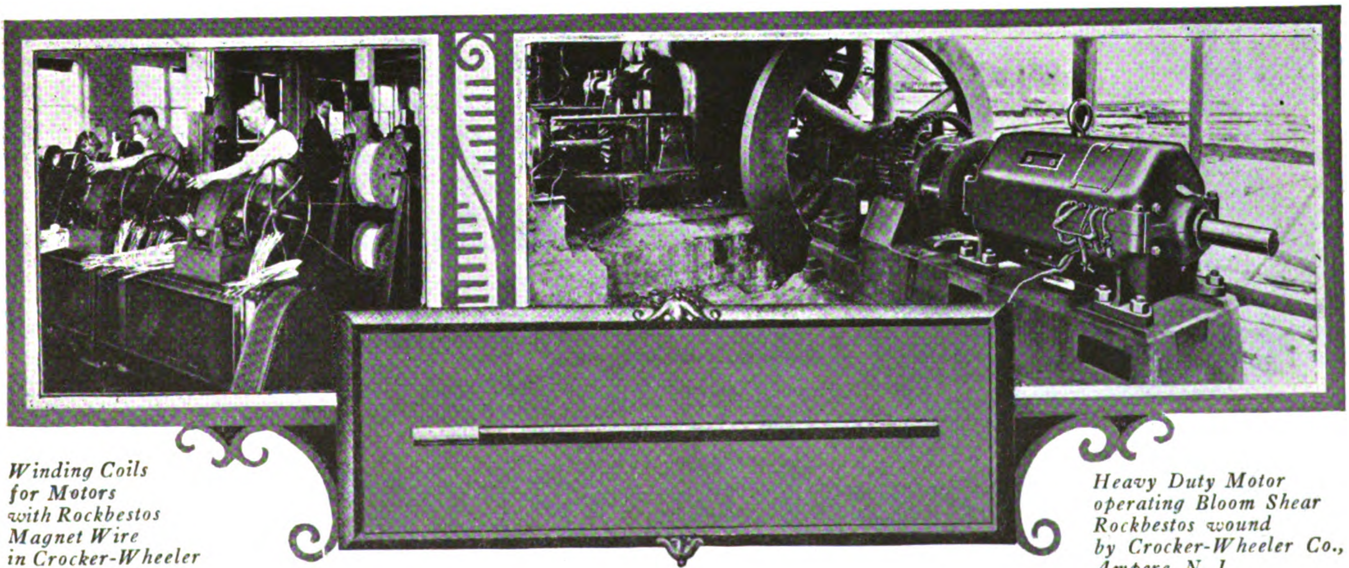
There are unlimited uses for asbestos covered wire and cable in industrial plants, and Rockbestos will give better service and greater protection against accident, because they are so well made. Our engineers and a complete research laboratory are ready to help plant engineers in selecting the proper wire for the job.

Magnet wire for motors
Switchboard wire
Fixture wire
Cables

ROCKBESTOS PRODUCTS CORPORATION

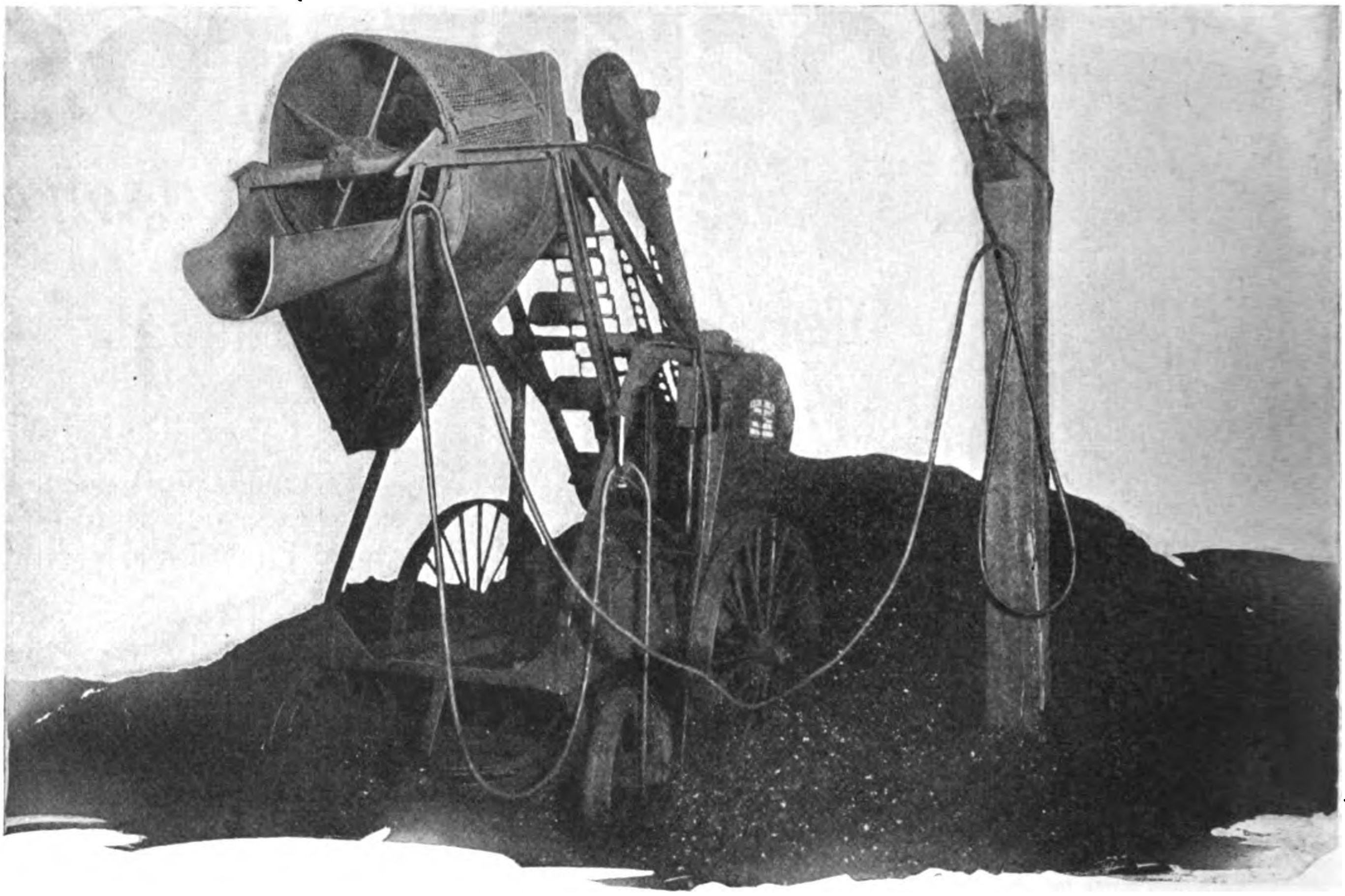
A copy of our Blue Book on wire will be sent cheerfully.

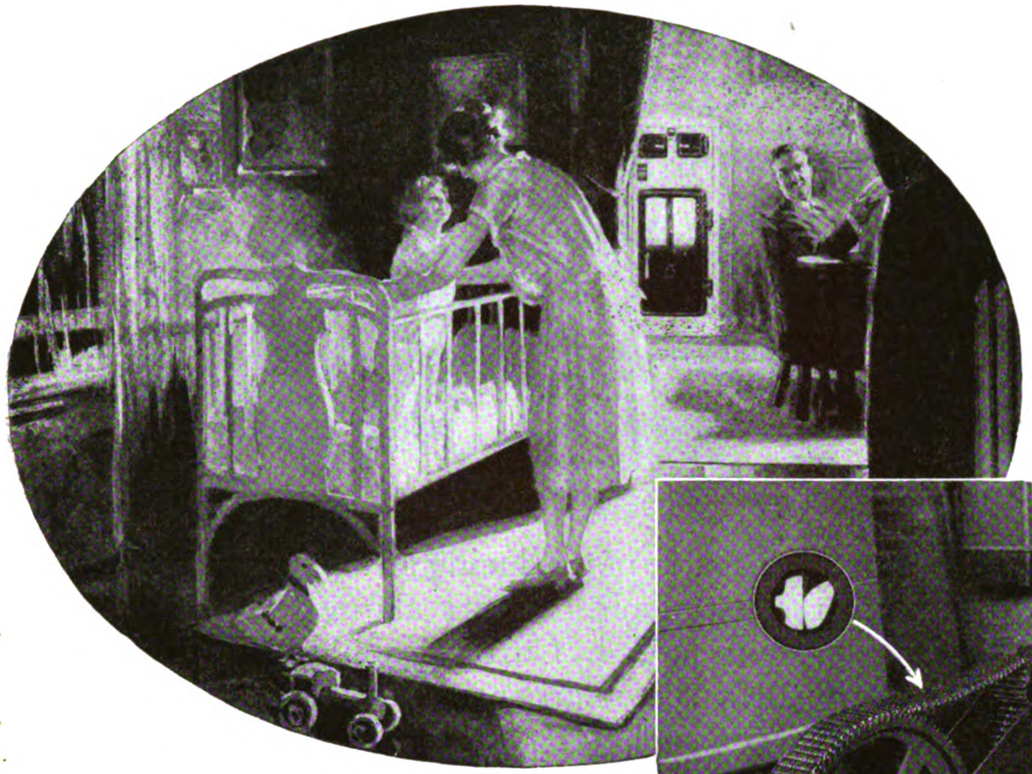
5942 Grand Central Term. Bldg., New York — NEW HAVEN, CONN. — Madison Term. Bldg., Chicago



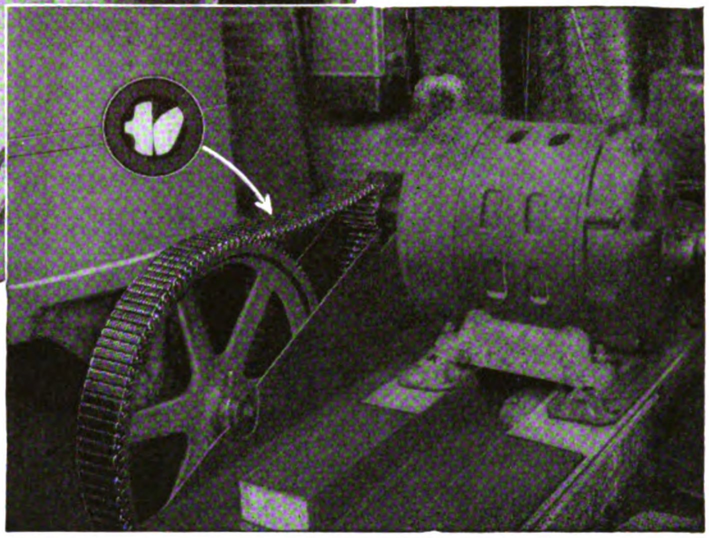
Winding Coils for Motors with Rockbestos Magnet Wire in Crocker-Wheeler Company's Plant

Heavy Duty Motor operating Bloom Shear Rockbestos wound by Crocker-Wheeler Co., Ampere, N. J.





20 H.P. Morse Silent Chain Drive from motor to sand mixer, American Radiator Co., Buffalo, N. Y. Driver, 725 r.p.m.: Driven, 112 r.p.m., 36 inch centers.



MORSE DRIVES and AMERICAN RADIATORS

IDEAL BOILERS and American Radiators economically provide heat and make many homes warm and comfortable. Back of this well-known line of heat producers, there must necessarily be efficient manufacturing processes and dependable equipment.

At the plant of the American Radiator Co., Morse Silent Chain Drives contribute to dependable and low-cost production by keeping machines in continuous operation. Their sustained efficiency of 98.6%, their flexibility and positive action—these and numerous other features are helping to solve production problems for many nationally known concerns.

Over 6,000,000 H.P. in use, one tenth to 5,000 H.P., 6,000 to 250 r.p.m. and slower. The nearest Morse Transmission Engineer is always available.

MORSE CHAIN CO., ITHACA, N. Y., U. S. A.

Morse Engineers are always available at:

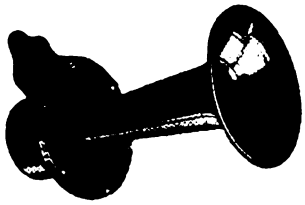
ATLANTA, GA. . . . . 702 Candler Bldg. Earl F. Scott & Co.
BALTIMORE, MD. . . . . 1002 Lexington Bldg.
BIRMINGHAM, ALA. . . Moore Handley Hdwe. Co.
BOSTON, MASS. . . . . 141 Milk St.
BUFFALO, N. Y. . . . . Ellicott Square Bldg.
CHARLOTTE, N. C. . 404 Commercial Bank Bldg.
CHICAGO, ILL. . . . . 112 W. Adams St.
CLEVELAND, OHIO . . . . 421 Engineers Bldg.
DENVER, COLO. . . . . 211 Ideal Bldg.
DETROIT, MICH. . . . . 7601 Central Ave.
LOUISVILLE, KY. 516 W. Main St. E. D. Morton Co.
MINNEAPOLIS, MINN., 413 Third St. Strong-Scott Mfg. Co.
NEW ORLEANS, LA., Queen & Crescent Bldg., 334 Camp St. A. M. Lockett & Co., Ltd.
NEW YORK, N. Y. . . . . 50 Church St.
OMAHA, NEB. . . . . 727 W. O. W. Bldg., D. H. Braymer Equip. Co.
PHILADELPHIA, PA. . . . 803 Peoples Bank Bldg.
PITTSBURGH, PA. . . . . Westinghouse Bldg.
SAN FRANCISCO, CALIF. . . . . . Monadnock Bldg.
ST. LOUIS, MO. . . . 2137 Railway Exchange Bldg.
TORONTO, 2, ONT., CAN., 50 Front St. E., Strong-Scott Mfg. Co.
WINNIPEG, MAN., CAN., Dufferin St., Strong-Scott Mfg. Co.

1240

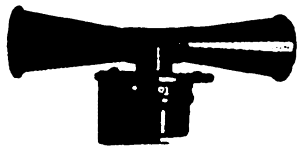
Industrial Signals

Electric Vibrating Horns

Type No. 3



Megaphone



Two Way

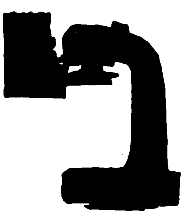
Three Way

Schwarze Industrial Horns are capable of producing an audible sound above the hum of machinery in the noisiest plants. As fire alarms, superintendent and general call signals they are unexcelled. Current supply can be high or low voltage A.C. or D.C. Further particulars, prices, catalogs, etc., gladly sent on request.

Manufactured by

Schwarze Electric Co.
Adrian, Mich., U. S. A.

Keystone Contact Rail Material—



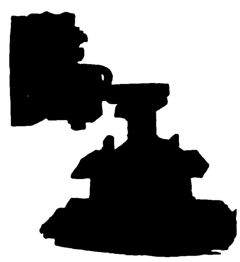
Contact rail shoe assembly for under-running contact.

Designed and manufactured to give long service and constant contact on cranes, conveyors and other electric industrial hoisting and hauling systems.

Our engineers will co-operate in the selection and installation of various types to meet your requirements. ESSCO Catalog sent on request.

ELECTRIC SERVICE SUPPLIES CO

PHILADELPHIA **17th and Cambria Sts.** NEW YORK **50 Church St.** CHICAGO **Illinois Merchants' Bank Bldg.**
PITTSBURGH 1123 Bessemer Building BOSTON 88 Broad St. SCRANTON 316 N. Washington Ave. DETROIT General Motors Bldg.
Lyman Tube & Supply Co., Ltd., Montreal, Toronto, Vancouver.



Contact rail shoe assembly for over-running contact.

MAGNET WIRE

MARING PROCESS

THE MARING PROCESS insures constant current-carrier service through the combination of sound basic principles with exclusive, proven methods of manufacture.

ENAMELED, COTTON AND SILK COVERED

MARING WIRE COMPANY

Factory and General Offices

MUSKEGON, MICHIGAN

"Performance is the real measuring stick of service!"

D. E. FELT, PRESIDENT
WM. F. BABCOCK, SECY & TREAS.
JOHN C. NEVINS, VICE PRES. & GEN. SALES MGR.
G. S. BOLLENSEN, FOREIGN MGR.

CABLE ADDRESS "DORRFELT"
CODES USED: A B C 5TH ED., LIEBER, WESTERN UNION

1713-1735 NORTH PAULINA ST
CHICAGO, U.S.A.

October 5, 1926.

The Electric Storage Battery Co.,
Industrial Truck Dept.,
Marquette Bldg.,
Chicago, Illinois.

Gentlemen:

With any kind of equipment, performance is the real measuring stick of service. Performance not only tells the whole story of its worth and merit but carries with it the conclusive truth of its truth and accuracy.

It occurred to us, therefore, that you might be interested in the record of service given by your Exide Ironclad battery used in our Elwell-Parker house trucks. The first battery you put in was placed in service in January, 1919 and it is still doing satisfactory work. In February, 1925 we found it necessary to renew a battery which was placed in service September, 1919, it being five years old at the time it was renewed. The last Exide battery you installed in the new Elwell-Parker truck went into service on August 3, 1923, since which time it has been operating satisfactorily every day with every promise of several more years of usefulness.

In addition to the excellent results which we have had from the Exide battery, and which we feel has contributed much to their satisfactory performance and durability, is the regular and careful servicing given them by your Company -- which we very much appreciate.

Very truly yours,

FELT & TARRANT MFG. CO.

TJW: CC

Exide
IRONCLAD
BATTERIES

The performance of Exide-Ironclad Batteries receives another striking tribute

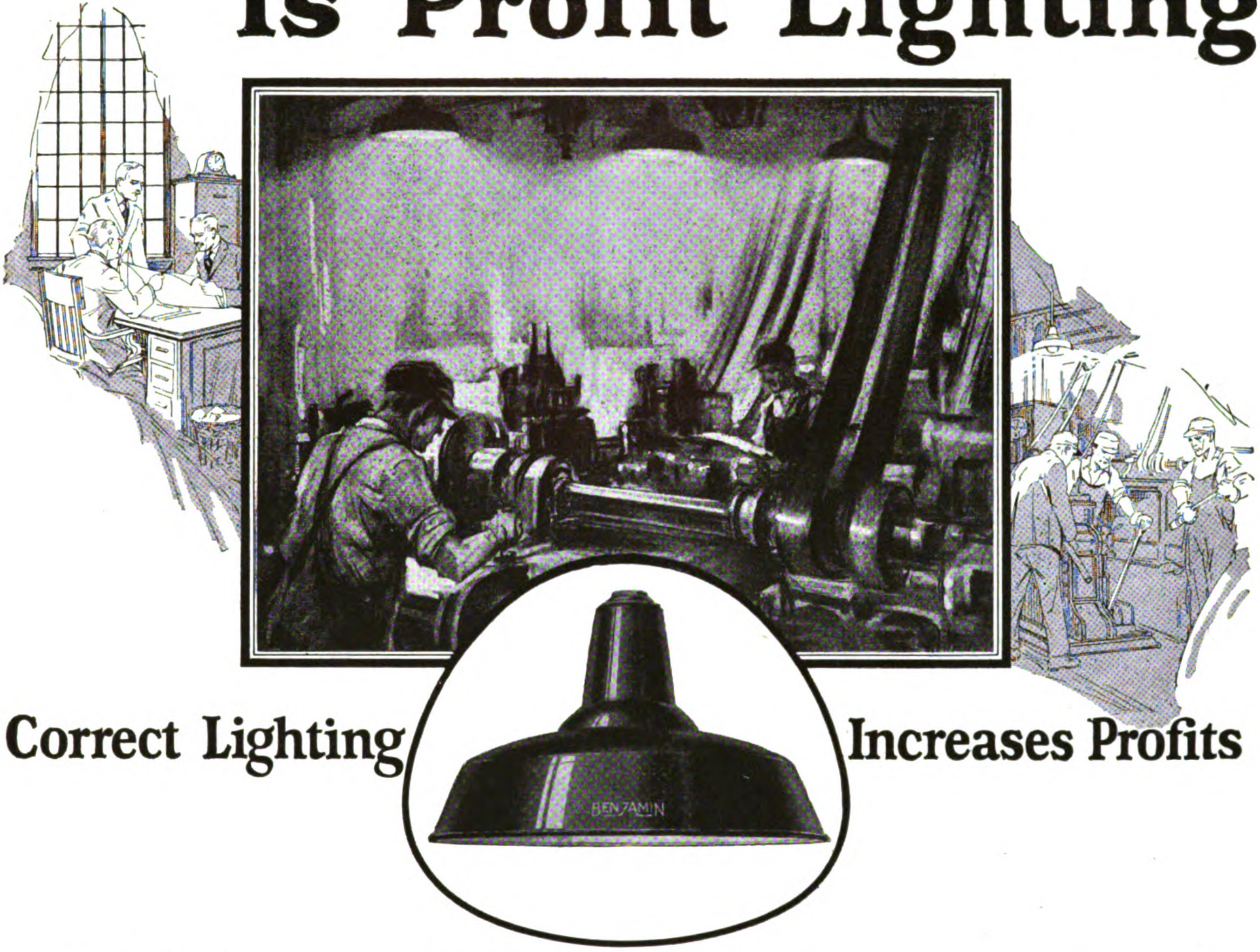
IT is impressive when a prominent electric industrial truck user speaks in such glowing terms of the performance of Exide-Ironclad Batteries. Yet the Felt & Tarrant Mfg. Co. is only one of the hundreds of firms that have discovered what the dependability and long life of Exide-Ironclad Batteries can do to lower material-handling costs.

It will pay you to know all about this remarkably dependable battery. Write now for a copy of our booklet, "Facts for consideration in selecting a Storage Battery," form number 2865.

THE ELECTRIC STORAGE BATTERY COMPANY, Philadelphia

Exide Batteries of Canada, Limited, 153 Dufferin Street, Toronto

Planned Lighting Is Profit Lighting



Correct Lighting Increases Profits

Good lighting is as essential to production as modern machinery or proper arrangement of operations. Unless men can see well they cannot do nor give their best. No matter what the program may be the final test of accuracy and good performance will rest upon ability to see.

The time has passed when men can be driven. They must be led into greater productiveness through the stimulus of proper surroundings and adequate facilities.

In thousands of plants that are operating on the profit side, Benjamin industrial lighting equipment is a saving factor in their efficiency.

When Correct Industrial Lighting is under consideration our Catalog 24 will be found very helpful. Our nearest office will gladly supply a copy.

Benjamin Electric Mfg. Co.

New York: 247 W. 17th Street — 120-128 S. Sangamon Street Chicago — San Francisco: 448 Bryant Street

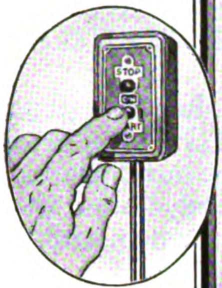
Manufactured in Canada by the Benjamin Electric Mfg. Co. of Canada, Ltd., Toronto, Ontario.

Benjamin-Starrett Panel Boards

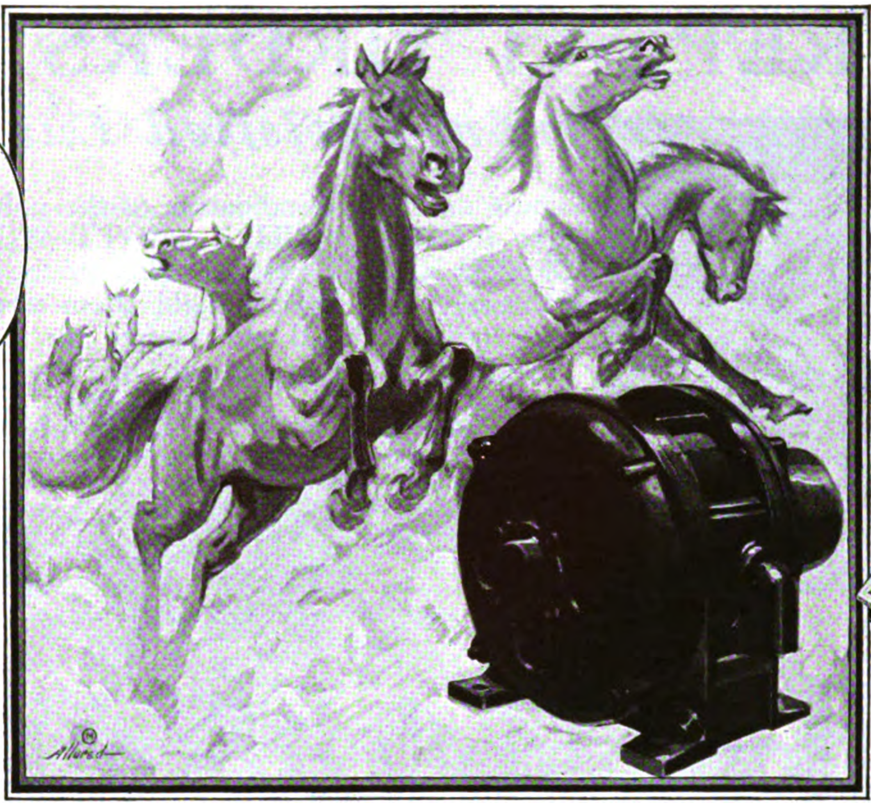
BENJAMIN

TRADE MARK

Benjamin Industrial Howlers



The trend of industry is decidedly toward Cutler-Hammer Push Button Control. Merely a touch of the proper button right at the machine starts, accelerates, decelerates, regulates the speed or stops the motor as required. The controller is placed in any safe, convenient location. Saves time, affords better control and provides greater safety—a logical step in advance.



This booklet "Industry's Electrical Progress" puts into concise, interesting form the story of savings through modern motor control. Write for your copy today.

Motors by themselves are only brute force

The economies that electric power brings to industry depend on correct motor control

IT seems so simple—and yet in so many plants this basic truth is often neglected.

Motors by themselves are only brute force!

Engrave it on the minds of the men who design *your* equipment. Burn it into the memory of those who specify—those who buy. For today it is the battle cry in the fight to reduce manufacturing costs!

Every motor you put into service offers the opportunity of minimum operating expense. It can save in power costs. It can speed up production. It can save in labor—that major item of manufacturing burden. But you are trifling with opportunity if you leave these possible economies to chance—these economies that result not from the mere installation of motors, but from the production efficiency you are able to obtain through the perfect control of their brute force.

Competitive conditions today demand the accurate powering of equipment. Plan your drives considering the work to be done. That means the choice of motor control equipment first—choice of the type of control equipment that affords maximum speed of production—that ties in closest with the manual operations involved. The proper type of motor can *then* be selected to give maximum results.

Carry this story to the men of your plant! Have them check the motors you have in service. Like many other plants, you will find that modern motor control on many existing drives will pay for itself in a few months—and then add steadily to profits.

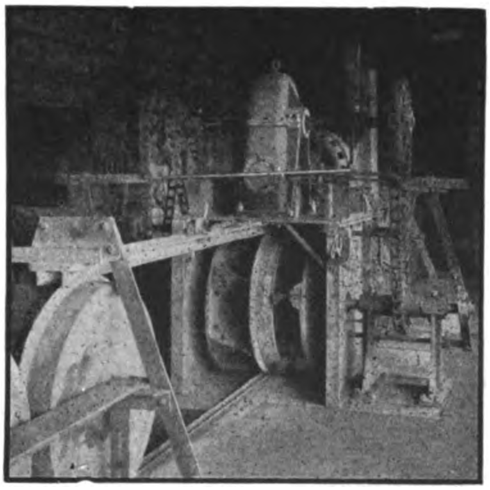
If you desire, Cutler-Hammer field engineers will gladly counsel with your plant men or consulting engineers to determine where savings may be obtained—to show them the latest control equipment available for every need. Their recommendations are based on more than thirty years' experience. This service is also offered for the planning of new drives, and their co-operation does not place you under any expense or obligation.

The CUTLER-HAMMER Mfg. Co.
Pioneer Manufacturers of Electric Control Apparatus
1219 St. Paul Avenue Milwaukee, Wis.

CUTLER-HAMMER

Industrial Efficiency Depends on Electrical Control

REPEAT ORDERS



Horsburgh & Scott Worm Gear Speed Reducer driving Car Wheel Cleaner, Motor 15 H.P. at 1200 R.P.M. Speed Reduction 40 to 1.

from Satisfied Customers

These are a true indication of the value of a product. HORSBURGH & SCOTT WORM GEAR SPEED REDUCERS are repeatedly purchased by concerns who have bought them and found that they have fulfilled our claims for Dependability, Durability and Economical Operation.

The illustration is that of a type B unit, with gear shaft extended in both directions, operating a car wheel cleaner. The first unit, purchased a number of years ago, has not only resulted in repeat orders but also an expression of complete satisfaction from the user.

An engineering department capable of consulting with you on every problem of power transmission or speed reduction is at your service.

The Horsburgh & Scott Co.

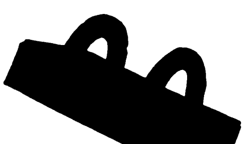
"Gear Makers Since '89"

5114 Hamilton Ave. CLEVELAND, U. S. A.

Gears for Every Industrial Purpose—Worm—Bevel—Herringbone—Spur—Spiral—Hardened Heat Treated Gears—Non-Metallic Gears and Pinions

CORRECT

Commutator Maintenance



To get the best service from your motors and generators, you must keep their commutators in perfect condition.

The Acme Commutator Smoothing Stone and the Aurand, Jr., Commutator Slotter are an ideal combination for the efficient and economical maintenance of commutator surfaces. They do the work accurately, quickly, and easily.

Your name and address on a card will bring full details of our entire line of commutator maintenance equipment, viz:

Portable Blowers, Commutator, Polish Cement, Washing Fluid, Turning and Grinding Tools, Fuse Pullers, Air Gap Gauges.

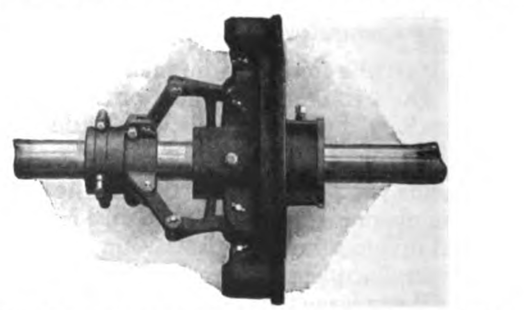
GREEN

EQUIPMENT CORPORATION
MONADNOCK BLOCK CHICAGO, ILLINOIS

WELLER

Steel Plate

FRICTION CLUTCHES



NOTE the Absence of Projecting Bolts or Lugs
Also Compact, Solid, General Lines.

WELLER MADE CHICAGO

We make a Complete Line of
Transmission Machinery
For Belt or Rope Drives
also
Conveying Machinery

Send for Catalogue 35A Transmission Machinery

WELLER MFG. CO.

1820-1856 N. Kostner Avenue, Chicago, Ill.

SALES OFFICES:

New York Buffalo Detroit Omaha

30c More a Day for Lighting Increases Production Six Per Cent

THIS is the actual experience of the Standard Register Company of Dayton, Ohio. While it seems outstanding, over 15,000 plants in various parts of the country, last year, made similar savings.

Practically all of them thought they had good lighting until the change was made. Now they *know* the many benefits obtainable from PROPER lighting and how little it costs to make the change.

The lighting of the composing room of the Standard Register Company was brought up to standard through recommendations of the Dayton Power & Light Company. In Dayton alone, 58 factories improved their lighting last year.

Industrial Lighting Fact No. 2

You, too, can increase your production by bringing your lighting up to the proper standard. Without cost your local electric light company will gladly show you how.

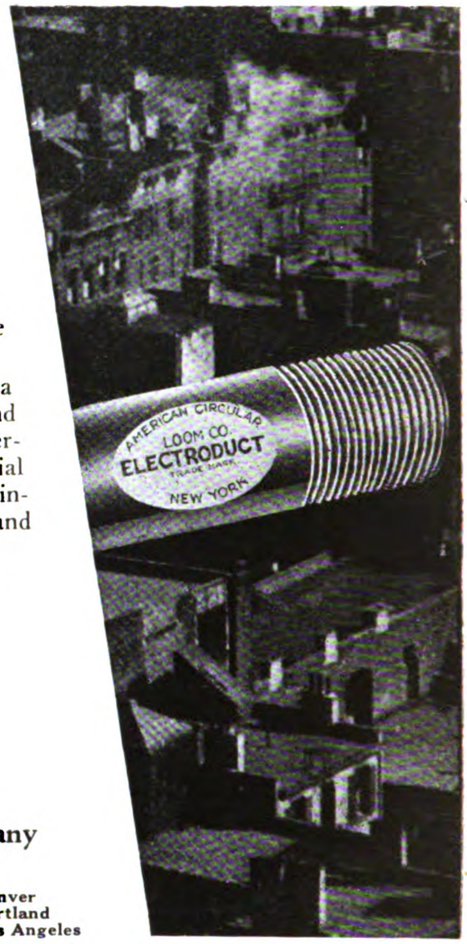
Industrial Lighting Committee, National Electric Light Association
29 West 39th St., New York

Electroduct—good for the life of the buildings!

"Xduct"—the galvanized conduit with the strong clean threads.

It is smooth inside and outside because it is a National Tube Company's scale free pipe. And being smooth before enameled—it is smooth afterwards. It's easy to handle because of its special acid and alkali resisting coat of enamel both inside and out. "Electroduct" fishes, bends and cuts easily—and has clean perfect threads.

Try it yourself. Let us send you a sample.

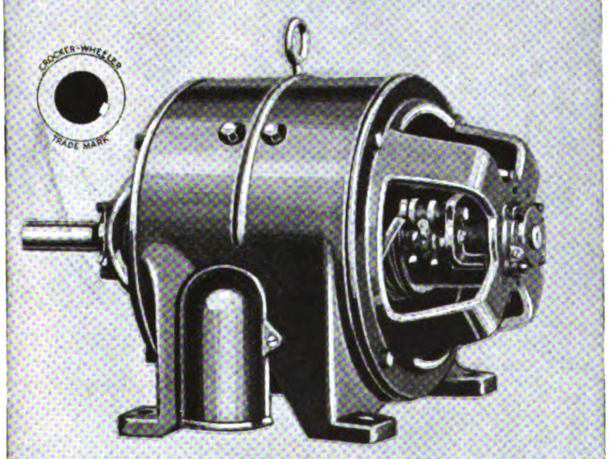


AMERICAN CIRCULAR LOOM CO. TRADE MARK

American Circular Loom Company
90 West Street, New York City

Boston, Philadelphia, Atlanta
Pittsburgh, Cleveland, Buffalo, Chicago
Denver, Portland, Los Angeles

CROCKER-WHEELER

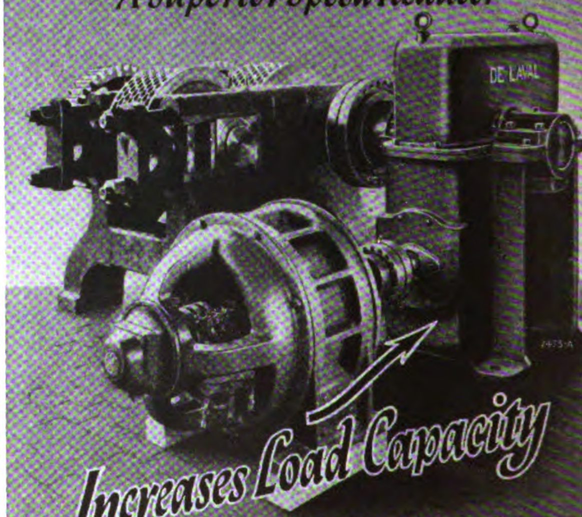


D. C. and A. C. Motors from ½ H. P. up.
D. C. and A. C. Generators and Motor-Generator Sets from 100 Watts up.

CROCKER-WHEELER ELECTRIC MFG. CO.
AMPERE, NEW JERSEY
Branch Offices in Principal Cities
Foreign Distributor: International Standard Electric Corp.

MOTORS & GENERATORS

De Laval
Worm Reduction Gear
A Superior Speed Reducer



Increases Load Capacity

This gear reduces the 600 RPM. of a 30 HP. motor to the 12 RPM. required by a briquetting press.
Ask for Catalog R.

De Laval Steam Turbine Co.,
Trenton, New Jersey

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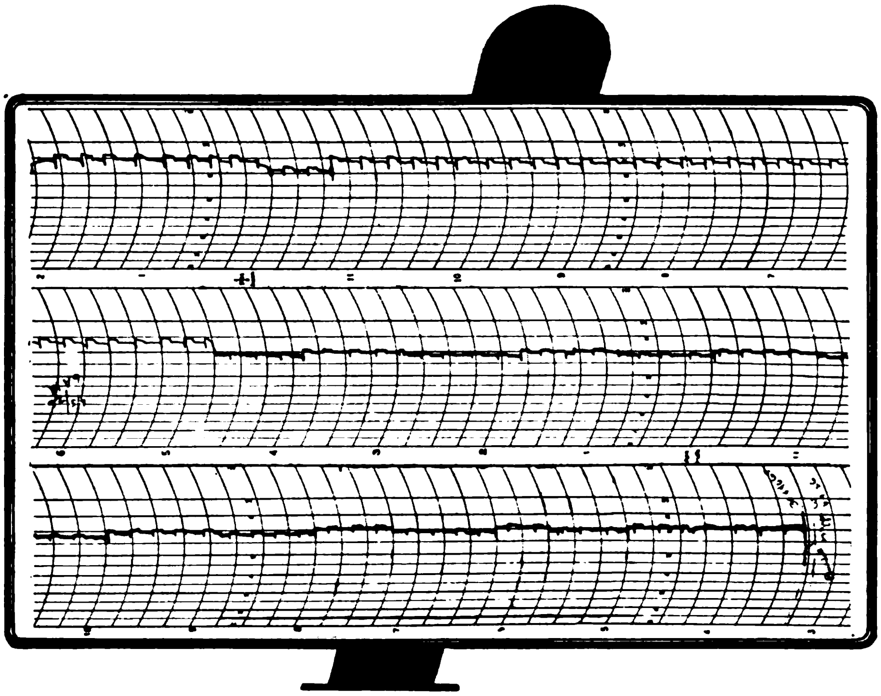


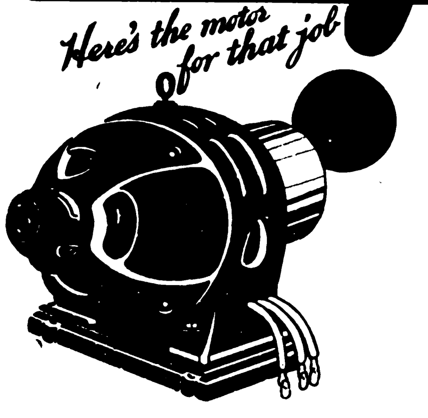
DOES POWER FACTOR COUNT?

Why and How

At the throw of the switch, TR Automatic Self-Start Motor starts on a high resistance squirrel cage, placed at the bottom of the rotor slots. At a certain predetermined speed, a three point centrifugal switch closes the circuit on a low resistance winding at the top of the slot, bringing it into operation and paralleling it with the high resistance winding. The motor then operates as phase wound, constant speed, the two windings dividing the load.

External starters are eliminated. In thousands of installations, neither motors nor switches have ever given trouble. Starting current is exceptionally low, starting torque high, and the motor will carry heavy overload.

This is a brief description. Full details will be found in this bulletin. Write for it today.



It certainly does—

Low power factor means waste power which somebody must pay for.—Even where there is no penalty, it is eventually reflected in rates.

It is necessary to overmotor when ordinary induction motors are placed on hard starting jobs. Overmotoring always causes bad power factor.

TR Self Start Heavy Duty Motors deliver starting torque of 275% to 300%, with starting current averaging 30% under N. E. L. A. requirements. No matter how heavy the start, you can power for running conditions—forget the starting load. Overmotoring is unnecessary.

Result—unusually high power factor for TR.

THIS RECORD SURPRISED US

Above is a 24-hour power factor chart taken by a central station on one 75 H. P. slip ring, and four TR motors ranging from 7½ H. P. to 75 H. P.

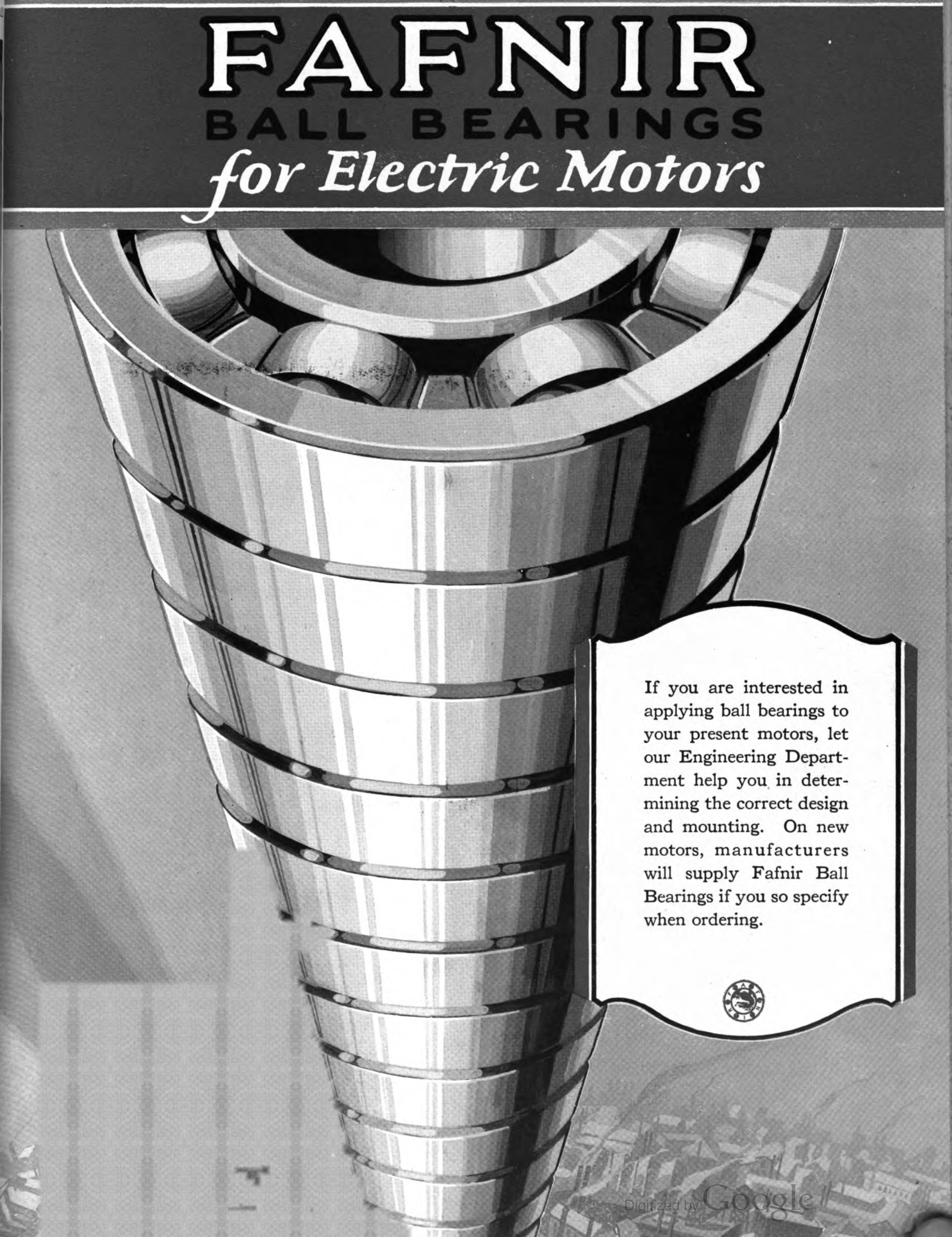
P. F. over all is around 90%. *P. F. for TR alone is 96%*—a surprise even to us.

Repeated tests of TR power factor show it to be always high, which with TR's superior operating characteristics makes it one of the most useful motors you can buy. If you standardize on TR, power factor correctives are unnecessary.

The Triumph Electric Corporation

Cincinnati, Ohio

THE ONLY AUTOMATIC SELF-START HEAVY DUTY TR MOTOR MADE IN 2 TO 125 H.P.


FAFNIR
BALL BEARINGS
for Electric Motors
If you are interested in applying ball bearings to your present motors, let our Engineering Department help you in determining the correct design and mounting. On new motors, manufacturers will supply Fafnir Ball Bearings if you so specify when ordering.

FAFNIR

"..... less trouble with windings .. no oil gets in ..."

Now that the chief engineer of a large foundry has changed over to ball bearing motors, he writes, *"We have less trouble with the windings and commutators due to the fact that no oil gets in . . ."*

As in this instance, so in hundreds of others. Experience shows that ball bearings do cut down motor trouble and failures. That ball bearings do get rid of the worries, time out, and costly expense of so many rewinding jobs caused by oil-soaked insulation and short-circuited coils.

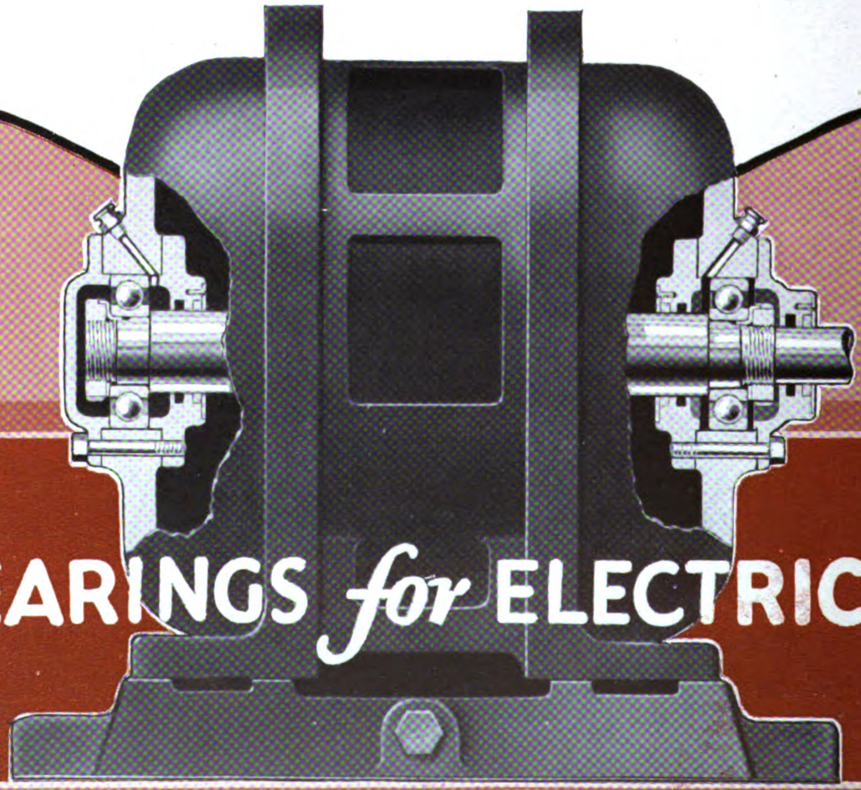
And here is why. Ball bearings, unlike plain bearings, virtually do not wear. Armature shafts in alignment stay in alignment. There is no chance of rotors dropping and abrading stator coils, or of air-gaps closing. Lubricant is retained in tightly sealed enclosures. It cannot leak out, neither can dirt get in. And a greasing once a year is the only attention a ball bearing motor needs.

This manual on ball bearing motors is of importance to every motor user. Copies will gladly be sent on request.

THE FAFNIR BEARING COMPANY, NEW BRITAIN, CONN.

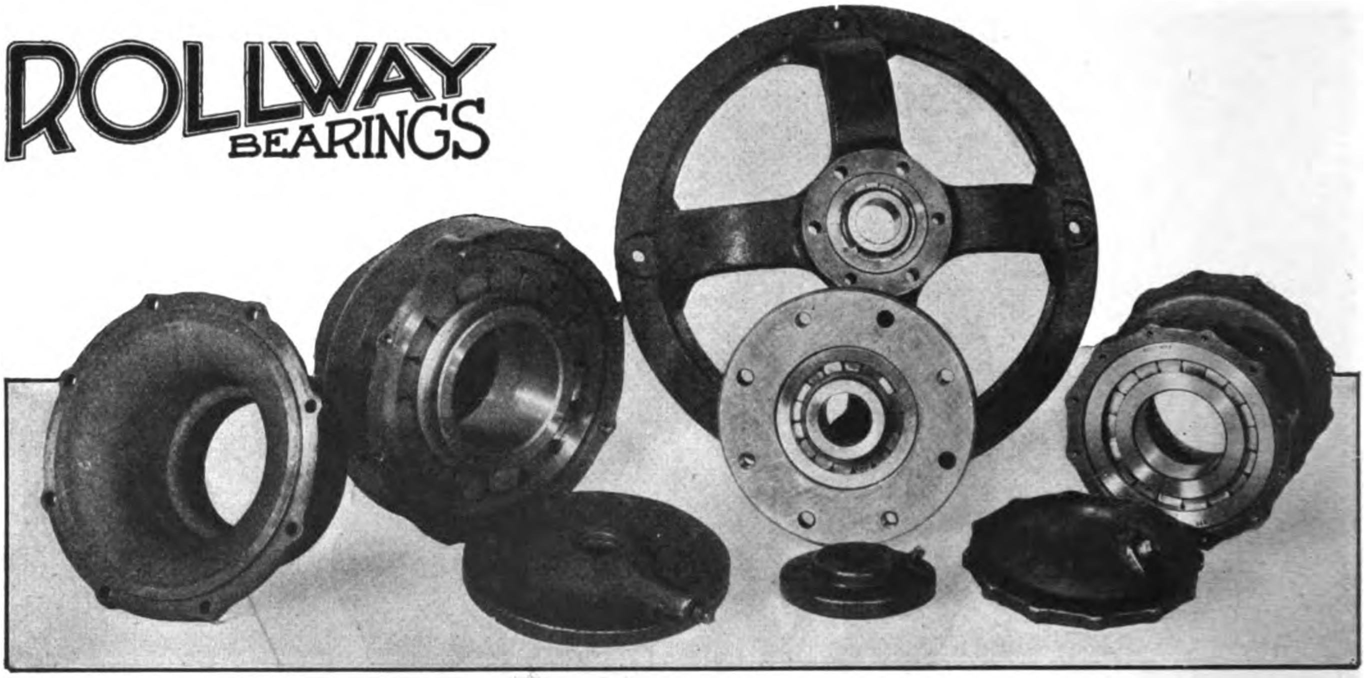
Makers of high grade ball bearings for every purpose— the most complete line of types and sizes in America.

NEWARK CHICAGO CLEVELAND DETROIT



BALL BEARINGS *for* ELECTRIC MOTORS

ROLLWAY BEARINGS



Rollway Bearings and Housings stop motor bearing troubles

On your old motors as well as on new ones, you can eliminate bearing troubles and the host of other troubles that originate in sleeve bearings by installing Rollway bearings and Housings. The Rollway Bearing Company has furnished bearings and housings for changing over thousands of sleeve bearing motors and is prepared to furnish change-over equipment for any standard motor. Send name-plate data on your most troublesome motor or our nearest engineering representative will call on request.

Rollway Bearing Company, Inc. **Syracuse, New York**

slip!

A slip of the belt is no fault of the belt

Tightening the belts does not prevent belt slip. This is a scientific fact. Cling-Surface preservative absolutely prevents slipping and enables you to run the belts slack, thereby increasing the arcs of contact, preventing hot-boxes, and often quadrupling the life of your belts. Besides, Cling-Surface prevents a large per cent of shut downs. The coupon represents an opportunity for you to effect large savings of power. In addition it will bring you the means of saving belts, machinery, fuel and money. Mail it today.

Cling-Surface—preserver of belts—has been made for thirty years by the only company whose sole product is belt treatment. It is used in every country of industrial importance in the world. It saves belts and machinery. It increases transmission efficiency and prevents all loss due to slipping.

Maddock Pottery, Trenton, N. J.

Cling-Surface *Preserves Belts— Eliminates Belt Slip*

CLING-SURFACE CO., 1020 Niagara St., Buffalo, N. Y.

Conditions in our plant are about as checked:

☐ cold ☐ hot
☐ damp ☐ dry
☐ dusty ☐ clean
☐ 3 gal. tin at $3.40 gal.
☐ 6 gal. tin at $3.25 gal. f.o.b. nearest warehouse.

CLING-SURFACE CO., 1020 NIAGARA ST., BUFFALO, N.Y.

Gentlemen: I am always willing to give a belt-saving, money-saving proposition a trial on its own merits. Send tin to fit conditions noted and of the size checked. If need be, I shall use the entire contents. If satisfactory I shall pay in 60 days. Otherwise no pay.

Company .... Attention.........

Address IE-12-26

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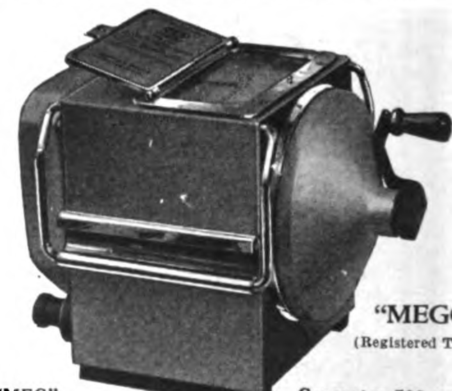

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"MEG" Insulation Tester

Generates 500 volts, d.c. Range 0 to 100 Megohms

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ARE you *guessing* at this important element of your electrical equipment—waiting for weak insulation to give trouble? Or do you attack the problem in the manner described in our latest "Megger" Catalog?

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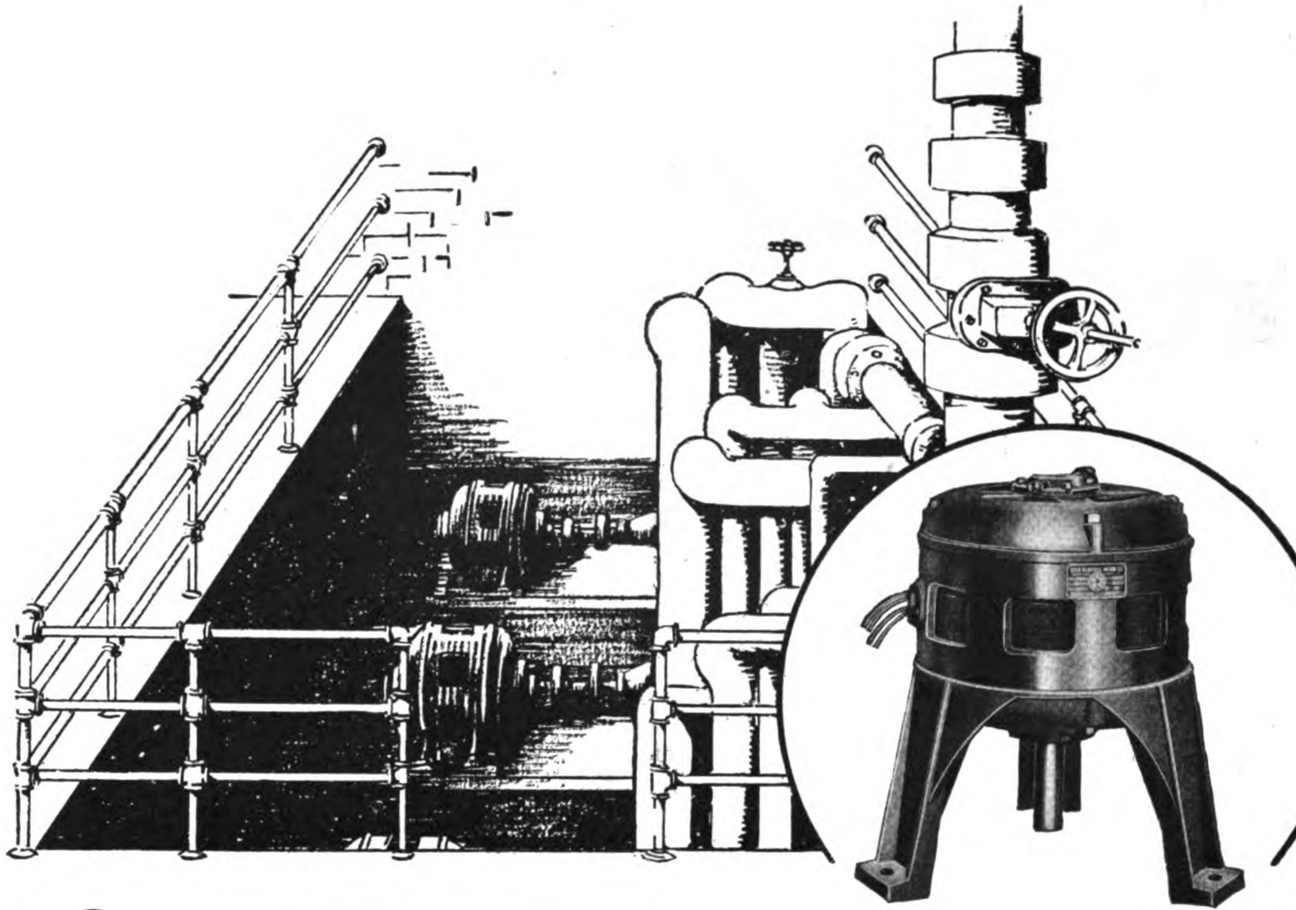

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Centrifugal—Rotary—Plunger

In the Star line there is a ball bearing motor for every type of pump. Ball bearings are best for medium and slow speed work, and are indispensable for the high speeds at which centrifugal pumps function. All Star motors are ball bearing motors.

The high starting torque requirements of plunger or slow speed rotary pumps are fulfilled by the Star double squirrel cage motor. This motor in sizes to 50 h.p. may be operated by an automatic switch, as it requires no compensator or rheostat.

Rugged and dependable simplicity characterize Star Motors. They are built both in A.C. and D.C. from ¼ to 100 h.p. horizontal and vertical, all speeds, all types and for all current characteristics.

Besides carrying a stock of standard motors, we maintain a department to develop motors for standard equipment.

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Columbus, Ohio, 75 E. Spring Street
Milwaukee, Wis., 1092 National Ave.
Chicago, Ill., 608 So. Dearborn St.
Cleveland, Ohio, Rockefeller Bldg.
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STAR ELECTRIC MOTOR COMPANY
140 Miller St., NEWARK, N. J., U. S. A.

Run your plant lighting circuits through—

WIREMOLD CONDUIT SYSTEM

This is an inexpensive, simple, practical method of surface wiring both large and small jobs.

Slip joints eliminate threading and reaming—thereby cutting installation costs.

Surface wiring is always accessible. Outlets may be located wherever needed after buildings are completed.

The Wiremold System makes a good looking, sturdy job.

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Stocked by leading electrical jobbers.

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Send coupon to-day

The Wiremold Company
Hartford, Conn.

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Do your **COMMUTATORS** run **HOT?**
Do you have **DESTRUCTIVE SPARKING?**
Are your **BRUSHES** wearing **GROOVES?**
Are your **MACHINES NOISY?**

Eliminate all these troubles and Prolong the Life of Machines

by equipping them with

The original and improved

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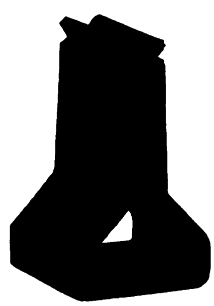
over 20 years in service

Let us equip a Generator or Motor for *you*. Make its *final acceptance* subject to your *approval after any reasonable period of operation.*

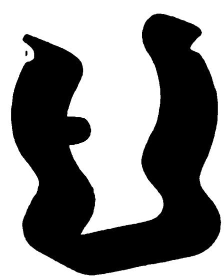
THE BAYLIS CO.
50 Nelson Street
BLOOMFIELD. N. J.

"The Clip with the Grip"



TYPE B

"Perfect Contact"



TYPE C

No more replacing of switch and fuse clip or fuses due to heat, overloading dust, vibration, moisture or corrosion.

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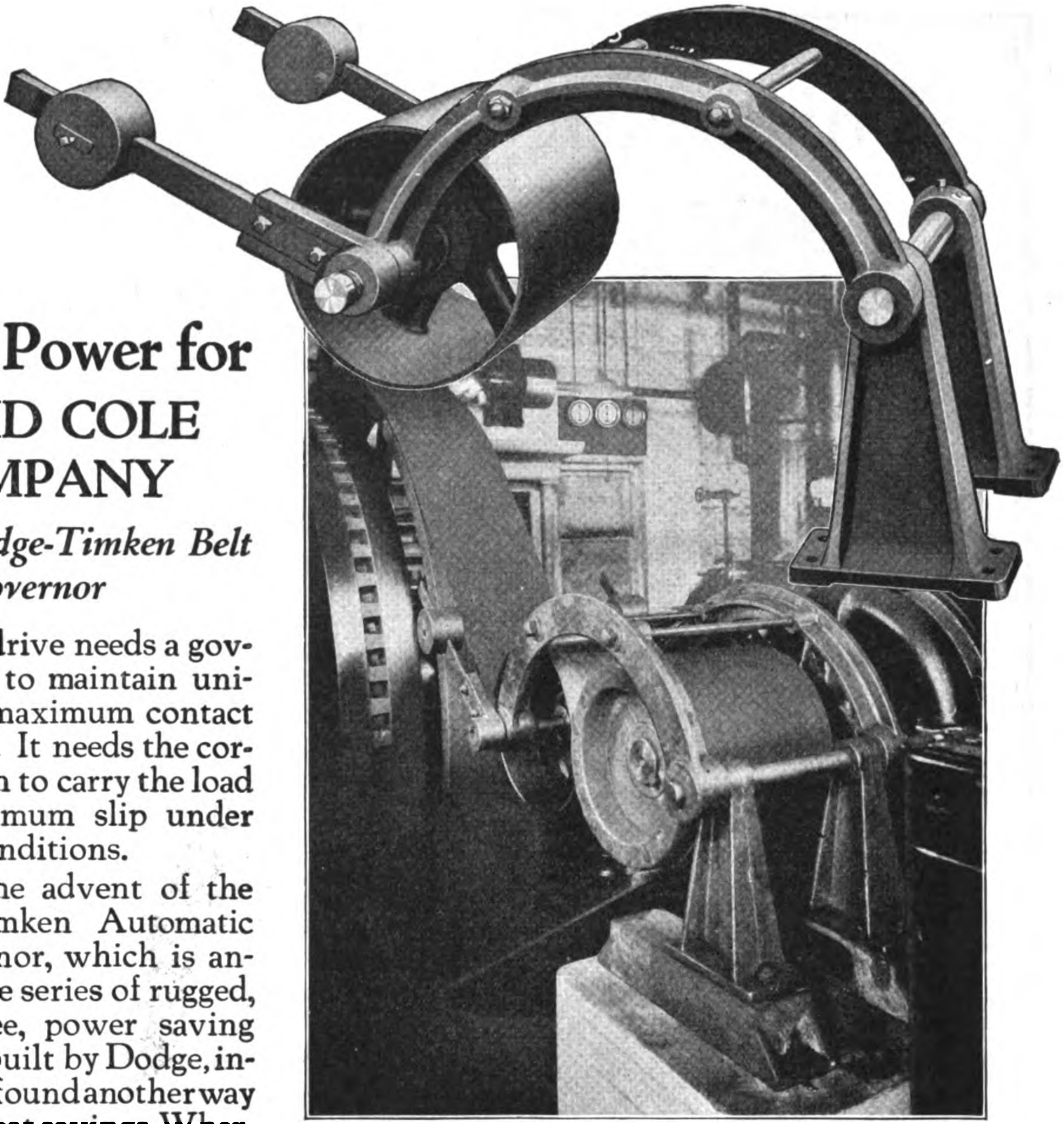
Start 1927 Right

Place Order for "The Clip with the Grip"

REINFORCED SWITCH & MFG. CO.
521-A BESSEMER BLDG., PITTSBURGH, PA.



Saving Power for DAVID COLE COMPANY

With a Dodge-Timken Belt Governor

A BELT drive needs a governor to maintain uniform and maximum contact on pulleys. It needs the correct tension to carry the load with minimum slip under varying conditions.

With the advent of the Dodge-Timken Automatic Belt governor, which is another of the series of rugged, trouble-free, power saving products, built by Dodge, industry has found another way to effect great savings. Wherever it is in use it is substantiating every claim for it.

Its application to all industry has been exceedingly successful. Above, is an illustration showing it in operation in the David Cole Co., Omaha, Neb. The Dodge-Timken Belt Governor can be applied to horizontal, angle or vertical drives. It is equipped with Timken Tapered Roller Bearings, which are designed for high-speeds, heavy loads, continous operation and severe service.

Our special bulletin, giving full particulars regarding this new Dodge-Timken development, will be sent on request.

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Fifteen District Sales offices located in Chicago, Milwaukee, Minneapolis, Cleveland, Cincinnati, Oneida, Boston, Philadelphia, New York, Newark, Atlanta, St. Louis, Houston, San Francisco and Portland cooperate with 500 leading mill supply and machinery dealers in making Dodge service immediately available to you.

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Power Transmission—Material Handling—Special Machinery

This Mark

stands for Abolite

Look for it on all enameled steel reflector installations where Abolites are specified.

It also stands for highly efficient lighting and a dependable product. One which the engineer can specify and know that his requirements will be fully covered.

To the user, Abolites offer a flexible equipment, mainly because of the various types of holder sockets and interchangeability of reflector shades to meet changing conditions in his plant.

Abolites are made in the following types:—

R. L. M. Dome
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Deep Bowl
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If you are not familiar with them, kindly write for catalog E-178. You will find it a handy reference book on industrial lighting equipment.

AB Products Division

The National Screw & Mfg. Co.

Cleveland, Ohio

That Electrical Fact You Want

—is here

This is the one standard electrical help containing all of the data, kinks, short-cuts, helps and other information that the practical electrician, wireman, lineman, contractor, plant superintendent and construction engineer needs.

Croft's

American Electricians' Handbook

By TERRELL CROFT

823 pages, flexible, pocket size, 900 illustrations, $4.00 net, postpaid.

The book is brimful of those facts which every man engaged in electrical work needs to know.

Think how much help you would be able to get from a convenient pocket-size handbook that gives you in one book—

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All these topics and many more are covered in this revised second edition of **Croft's Handbook.**

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Examine this helpful book for 10 days free. See what it is—what it gives you—how it can help you. There's no obligation to keep it—you can send it back if you don't want it. Take this opportunity to see it. Send your coupon now!

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FIGHTING OIL FIRES

Every precaution is taken by the large oil companies to prevent fire but they are well equipped to fight a fire and prevent its spreading if one does occur.

Pictured above is the station from which chemicals are pumped and distributed for fighting a fire in the plant of the Associated Oil Company at San Francisco.

An EC&M Automatic Compensator is installed in this station for controlling the operation of the electric motor which drives the fire pumps. Push button control through this Compensator makes it possible for anyone, without previous training, to start these pumps correctly.

This Compensator has its working parts totally immersed in oil and sealed in a cast iron case. No matter how infrequent its operation may be, this Compensator is always ready for work when the emergency arises.

Write for Bulletin 1042-*F*

THE ELECTRIC CONTROLLER & MFG. CO.

CLEVELAND, OHIO

BIRMINGHAM-BROWN-MARX BLDG.
CHICAGO-CONWAY BLDG.
CINCINNATI-1ST NATIONAL BANK BLDG.
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SAN FRANCISCO-CALL BUILDING
SEATTLE-524 1ST AVE. SOUTH
TORONTO-TRADERS BANK BLDG.

New "Circle T" Motor Starting Switch

No. 2361
Box 4" w. x 7½" l. x 2⅞" d.

3-Pole Tumbler Type 600 V. A. C.

Rating

2 H.P. 600 V.A.C.

No Fuse

No. 2361 List $5.00

Discounts Schedule C

THE *new* "Circle T" 3 pole Tumbler Switch meets a large demand for a small yet rugged switch for starting 3 phase motors 2 H.P. and below.

Note the following features:

1. **Small Size**
   (Box is only 4 in. wide x 7½ in. long x 2⅞ in. deep.)
2. **Very Rugged**
   No. 2361 is a heavy duty switch designed to stand the severe electrical and mechanical stresses of Motor Starting Work.
3. **Cover is removable**
   by taking out two screws.
4. **Very easily wired**
   (See cut showing cover removed.)
5. **¾ in. Knockout in each end.**
6. **Not necessary to remove switch from box for wiring.**

No. 2361
Cover removed.

Trumbull Electric Mfg. Co.

PLAINVILLE, CONN.

SAN FRANCISCO
595 Mission St.

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CHICAGO: 2001 W. Pershing Road

JACKSONVILLE, FLA.

That Year in and Year out Service

ROWAN

Impedance Starter

for

Squirrel Cage Induction Motors

ROWAN CONTROL

THE ROWAN CONTROLLER CO., BALTIMORE, MD.

ACME Safety Limit Stop

For all D.C. hoist motors

STRONG—SAFE

One moving part
Cheapest to install
Weather-proof

Adjustable cut-off, actuated by block. Automatic dynamic braking. All circuits constantly operative. Automatic connection to lowering circuit. 2000 in use.

Full information promptly on request

CO-OPERATIVE UTILITIES CO.

1503 Columbia Ave. Philadelphia

Shipment in One Day

On Standard Conway Clutches

Your order for any of the following Standard Conway Clutches will be shipped the day after it is received—telegraph your order when rushed. Other sizes and shaft diameters shipped in two weeks or less.

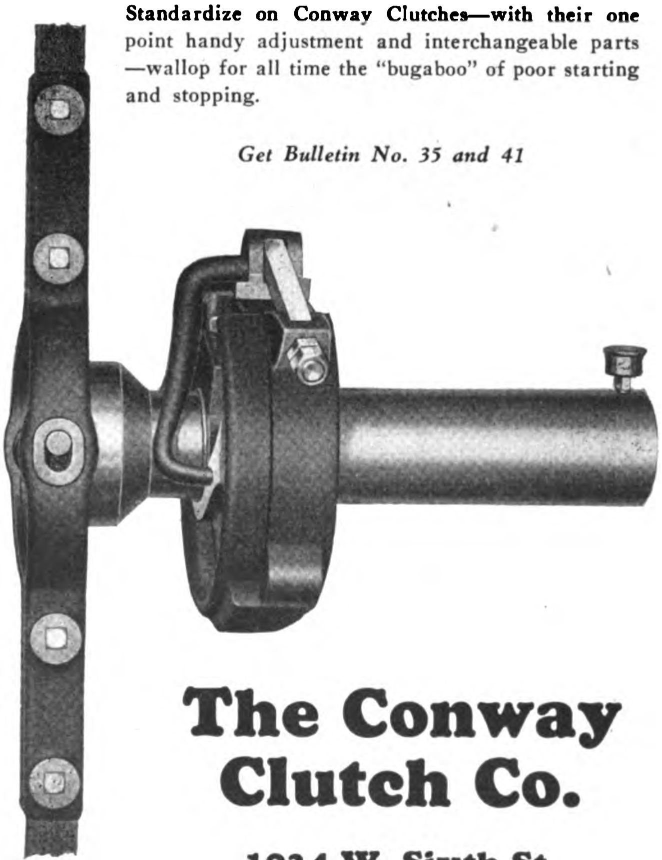
5 hp. at 100 r.p.m., $1\frac{11}{16}$ or $1\frac{15}{16}$, shaft, max. speed 500
10 hp. at 100 r.p.m., $1\frac{11}{16}$ or $1\frac{15}{16}$, shaft, max. speed 400
15 hp. at 100 r.p.m., $1\frac{15}{16}$ or $2\frac{3}{16}$, shaft, max. speed 380
20 hp. at 100 r.p.m., $2\frac{3}{16}$ or $2\frac{7}{16}$, shaft, max. speed 325
25 hp. at 100 r.p.m., $2\frac{3}{16}$, $2\frac{7}{16}$ or $2\frac{15}{16}$, shaft, max. speed 250

Easy engagement, quick release, drag free idling, that's Conway Clutches. Power always to deliver the maximum effort of the belt, chain or gear train—and a surprising amount of overload.

The Clutch that controls the Steam Shovel, Hoist, Loader, Dredge, Agitator, Conveyor or Baler should be packed with reliability.

Standardize on Conway Clutches—with their one point handy adjustment and interchangeable parts—wallop for all time the "bugaboo" of poor starting and stopping.

Get Bulletin No. 35 and 41



The Conway Clutch Co.

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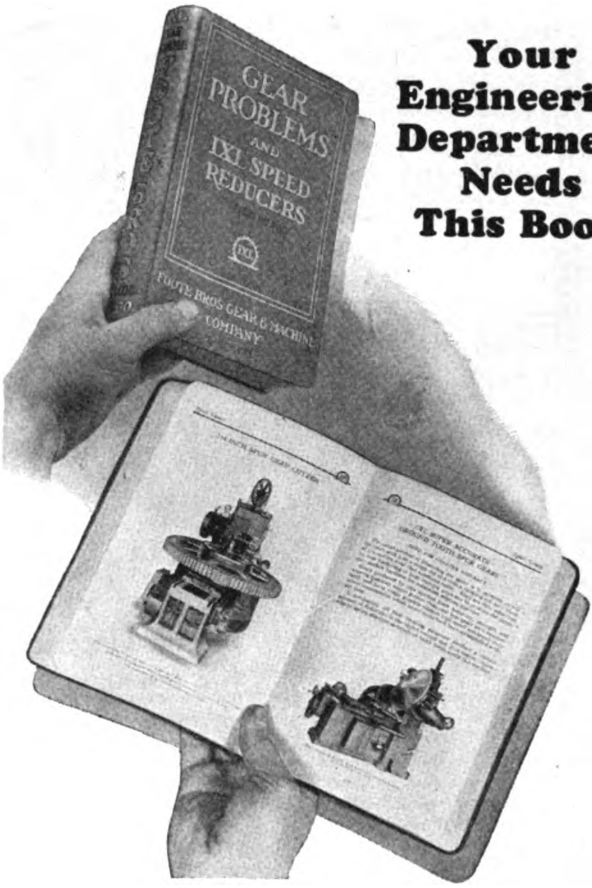
CINCINNATI, OHIO



Your Engineering Department Needs This Book

200 Pages of Engineering Information

200 Pages of 621 are devoted to mechanical engineering information, carefully selected, classified and indexed for easy and instant reference. You will find this book invaluable in figuring and selecting Gears and Reduction Units of all types to meet all requirements and estimating costs.

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FREE only to Executives and Engineers

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236-246 North Curtis Street
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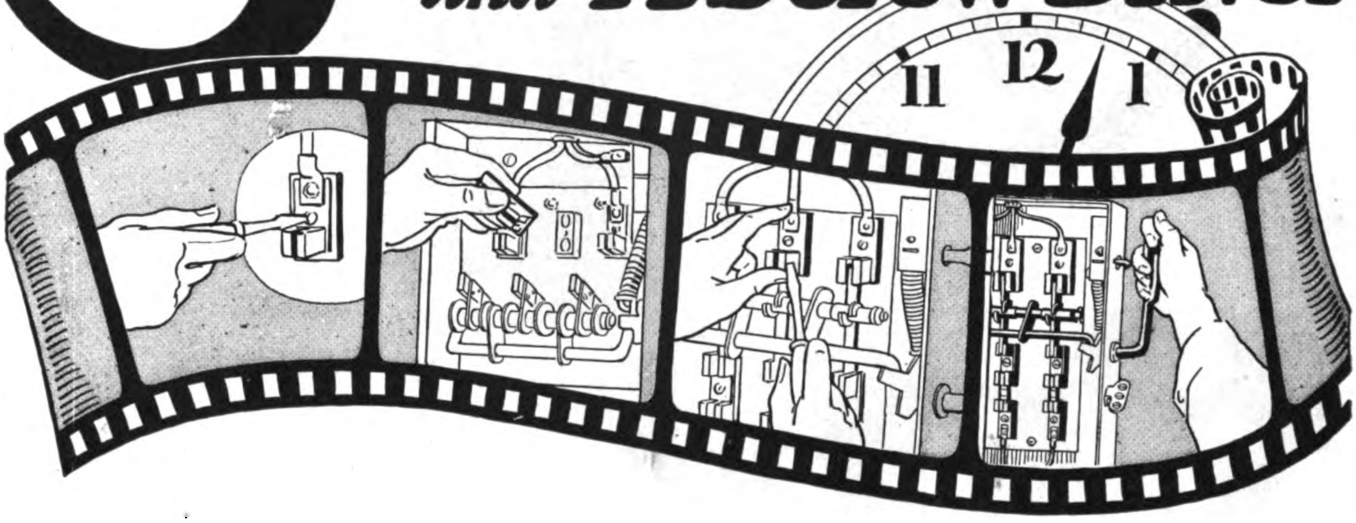
Sales Offices in All Principal Cities U. S. A. and Canada

R-172
FOOTE BROS. GEAR & MACHINE CO.
236-246 N. Curtis St., Chicago, Ill.
Please send without obligation a copy of Gear Problems and IXL Speed Reducers.

Name____________

Address____________

3 minutes! ..and A Screw Driver



Three minutes! That's all it takes any Square D salesman to prove Square D's simplicity of construction and ease of maintenance. For with a screw driver as his only tool he or anyone else can, in this brief period of time, remove any blade or jaw from the front without taking the base from the box or disconnecting all wires.

Individual base construction makes this possible, all current carrying parts being mounted on individual insulating bases.

It is this feature, combined with key-controlled accessibility, positive quick make-and-break action, enclosed mechanism, and assured safety that has achieved Square D its leadership—a leadership now solidly founded on more than 4,000,000 satisfactory installations.

Your careful inspection of these Square D advantages is invited. Ask your jobber or write us direct.

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BRANCH OFFICES: Toronto, Montreal (89)

BRANCH OFFICES
Boston, Minneapolis, New York, Syracuse, Pittsburgh, St. Louis, Philadelphia, Atlanta, Cincinnati, Milwaukee

SQUARE D
Safety Switch

BRANCH OFFICES
Cleveland, Kansas City, San Francisco, Chicago, Los Angeles, Baltimore, New Orleans, Buffalo, Indianapolis, Columbus


Are you ready
for the
clean up
that's coming?
Who's going
to replace
the scrapped
equipment?

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Box Numbers in care of any of our offices count 10 words additional in undisplayed ads.

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An advertising inch is measured vertically on one column, 3 columns—30 inches—to a page.

I. E.

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A SHOP foreman wanted for a large electric repair shop; must have had wide experience in handling help and capable of operating a shop of sixty or more workers; do not apply unless you have these qualifications; this shop is in the vicinity of Troy, N. Y. P-223. Industrial Engineer, Tenth Ave. at 36th St., New York.

COST accountant wanted, young man with sufficient training and experience in modern cost methods to work out and install cost system in plant with three hundred (300) employees in Northeastern Pennsylvania. Excellent opportunity for man with energy, tact, and initiative. Give full details of experience, education and salary. P-225, Industrial Engineer, 1600 Arch St., Phila., Pa.

MILLWRIGHT wanted, capable of installing electric motors; this means not one but several thousand; must be able to handle help and get results; steady position to the right man; this work is in the vicinity of Troy, N. Y. P-222, Industrial Engineer, Tenth Ave. at 36th St., New York.

WANTED: Young men to become service experts and maintenance men for high-grade mechanical and electrical equipment as used in large industrial plants and factories in electrically controlling and recording temperature and pressure. Excellent opportunities for promotion after thorough course of training in factory of large manufacturer of instruments and controllers. In applying describe mechanical ability, previous experience if any and education. Young single men preferred who are free for quick transfers. P-226, Industrial Engineer, Tenth Ave. at 36th St., New York.

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Get in the new profession. We can teach you meter engineering *by mail* at your own home during spare time. Successful graduates everywhere.

EARN $3,600.00 A YEAR

Central stations must have Electrical Meter Engineers. They pay high salaries. Write today. Just your name and address on a postal and we will send you full particulars free. Ft. Wayne Correspondence School, Dept. 80, Ft. Wayne, Ind.

Editorial Assistant

WANTED

Must be graduate electrical engineer with several years' good, industrial operating and maintenance experience, preferably in steel mill. Editorial experience not essential, but must write well. Excellent opportunity. Location New York. Give complete details, training, age, salary.

P-224, Industrial Engineer
Tenth Ave. at 36th St., New York City

EMPLOYMENT SERVICE

IF you are qualified for position between $2,500 and $25,000, and are receptive to negotiations for new connection, your response to this announcement is invited. The undersigned provides a thoroughly organized service, established sixteen years ago, to conduct confidential preliminaries, and assist the qualified man in locating the particular position he desires. Not an employment agency. Retaining fee protected by refund provision, as stipulated in our agreement. Send name and address only for description of service. R. W. Bixby, Inc., 258 Main Street, Buffalo, New York.

Distributors WANTED

WE are an old established highly rated concern and desire to make a few more permanent connections with Manufacturer's Agents and Distributors on an exclusive sales agency basis, who have proper connections and are in position to handle a fair volume of business. We manufacture the following lines of Ball Bearing Machines:

D. C. Commutating Pole Machines
A. C. Squirrel Cage Motors.
A. C. Slip-Ring Motors.
A. C. Double Squirrel Cage. Motors.
A. C. Multi-Speed Motors.

These machines are built in ratings up to 75 hp. and in all of the standard modifications. If interested, get in touch with us as we have a profitable proposition to offer.

AS-210, Industrial Engineer
7 South Dearborn St., Chicago, Ill.

A Fractional HP Motor or a Complete Power Plant

SAVE 35 to 45%

Buy Properly Rebuilt Electrical Power Equipment

Every machine completely overhauled and tested — Guaranteed

Write for Stock Bulletin

The FUERST-FRIEDMAN Co.
CLEVELAND, OHIO

MOTOR BARGAINS

New and Used

WE can supply your motor needs in any horsepower, A.C. or D.C., any type or make. Also motor-generator sets of all characteristics. Our motor service is complete. We buy, sell, rent, exchange or repair. Every motor guaranteed for one year against all electrical or mechanical defects. Write for our prices.

L. J. LAND 144 GRAND ST NEW YORK CITY

MOTORS MACHINERY Bought Rented Exchanged

We can save you considerable money on your motor and machinery needs. Large stock to select from. Everything guaranteed. Write.

Freidus Machy. Co. 174 Centre St., New York City.

MOTORS NEW and REBUILT

Buy With Confidence

Every Motor Guaranteed to Make Good or We Will.

ELECTRIC MOTORS CORP.
170 Centre St., New York, N. Y.

WANTED

WE BUY

ELECTRIC MOTORS

America's Pioneer Electrical Bargain House. Established 1893—High grade motors—generators, meters, transformers. Bought, sold, rented, exchanged. A $500,000 stock always available.

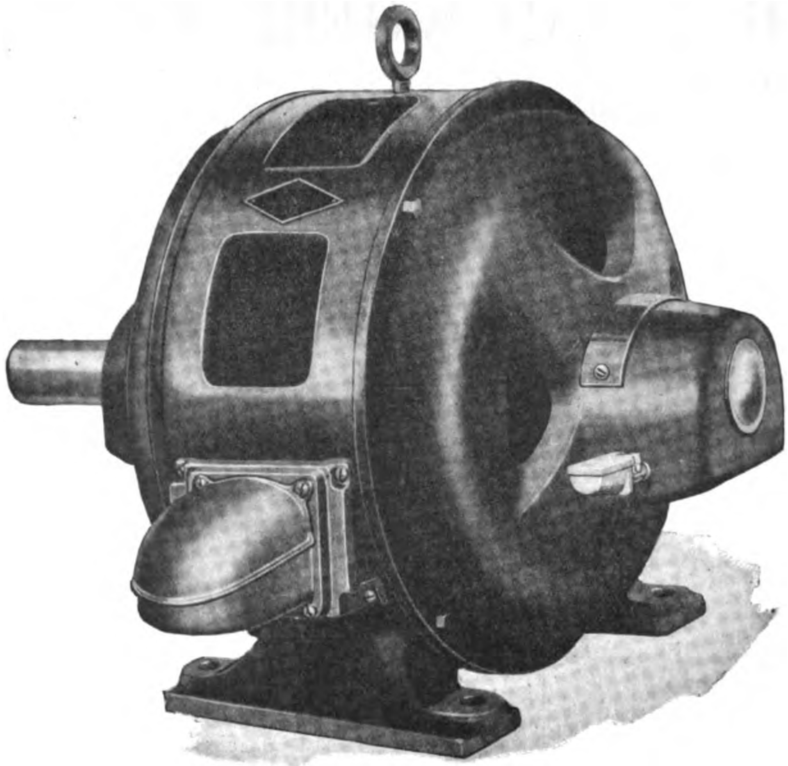
GREGORY ELECTRIC CO.
Works, 16th and Lincoln and Wood Sts., Chicago, Ill.

WANTED

USED TRANSFORMER

From 250 kva. to 450 kva., 11,000 to 220 v., 25 cy., 3 ph., self-cooled oil, indoor type. Will also consider 3 single phase Transformers. *Please furnish a complete description of what you have.*

KEOKUK STEEL CASTING CO.
Keokuk, Iowa.



Quality
Service

Right Prices
Courteous Treatment

EXPECT THESE QUALITIES IN YOUR MOTOR

1. Quiet operation (very important).
2. Interchangeable external dimensions for A.C. and D.C. in more than 80% of ratings.
3. Perfect dynamic balance.
4. Box type frames, feet integral, lessening skewing.
5. Heavy bearing brackets, lessening vibration.
6. Extra large bronze bearings, well lubricated.
7. Large oil reservoirs.
8. Indestructible Rotor construction.
9. Forced ventilation.

Built on a Creed Imperial Motors and Generators ***Meet These Specifications***

THE IMPERIAL ELECTRIC CO.

FACTORY: AKRON, OHIO

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ST. LOUIS, MO. 301 Buder Bldg.
CINCINNATI, O. 14 Greenwood Bldg.

WHAT AND WHERE TO BUY

Equipment, Apparatus and Supplies Advertised in this Issue with Names of Manufacturers and Distributors

Prospective purchasers in the electrical-mechanical market are invited to apprise us of their needs, assuming, of course, that the articles sought are not listed here.

Air Compressors
Allis-Chalmers Mfg. Co.

Ammeters, Voltmeters
(See Instruments, Electrical).

Armature Bearings
Rollway Bearing Co., Inc.

Armature Coil Spreaders
Armature Coil Equipment Co.
Mutual Foundry & Machine Co.

Armature Coil Winders
Armature Coil Equipment Co.
Mutual Foundry & Machine Co.

Armature Repair Machinery
Armature Coil Equipment Co.
Electric Service Supplies Co.
Mutual Foundry & Machine Co.

Barrels, Steel Shop
The Kirk & Blum Mfg. Co.

Batteries
Dry
National Carbon Co.
Storage
Electric Storage Battery

Battery Charging Apparatus
General Electric Co.
Westinghouse Electric & Mfg. Co.

Battery Parts
Electric Storage Battery Co.

Bearings
Ball
Dodge Mfg. Corp.
Fafnir Bearing Co.
New Departure Mfg. Co., The
Norma Hoffman Co.
Skayef Ball Bearing Co.
Roller
Norma Hoffman Co.
Rollway Bearing Co., Inc.
Standard Pressed Steel Co.
Timken Roller Bearing Co., The

Bearing Metal
Dodge Mfg. Corp.
General Electric Co.
Westinghouse Electric & Mfg. Co.

Bed Plates
Foote Bros. Gear & Mach. Co.

Bells, Electric
Schwarze Electric Co.
Westinghouse Electric & Mfg. Co.

Belts, Conveyer
Link-Belt Co.

Belt Dressing
Cling Surface Co.
Standard Oil Co., Ind.

Belts, Transmission
Link-Belt Co.

Bench Legs
Standard Pressed Steel Co.

Bleachers
Worcester Bleach & Dye Works Co.

Blocks, Pillow
Fafnir Bearing Co.
Rollway Bearing Co., Inc.
Standard Pressed Steel Co.
Weller Mfg. Co.

Blowers
Clements Mfg. Co.
De Laval Steam Turbine Co.
Green Equipment Corp.
Kirk & Blum Mfg. Co.
Martindale Electric Co.
Sturtevant Co., B. F.
Centrifugal
De Laval Steam Turbine Co.
Portable
Porter & Ross, Inc.

Blow-Pipe Systems
The Kirk & Blum Mfg. Co.

Bobs
Philadelphia Gear Works

Bolts, Nuts and Screws
Nat'l. Screw & Mfg. Co.
Sturtevant Co., B. F.

Books, Technical
McGraw-Hill Book Co., Inc.

Boosters
Allis-Chalmers Mfg. Co.
General Electric Co.
Westinghouse Electric & Mfg. Co.

Boxes
Clamp
Standard Pressed Steel Co.
Flood Outlet
Adam Electric Co., Frank
Hubbell, Inc., Harvey
Hanger
Fafnir Bearing Co.
Junction and Outlet
General Electric Co.
Hubbell, Inc., Harvey
Trumbull Electric Mfg. Co.
Westinghouse Electric & Mfg. Co.
Meter and Service
General Electric Co.
Trumbull Electric Mfg. Co.
Westinghouse Electric & Mfg. Co.
Sheet Metal Tote
The Kirk & Blum Mfg. Co.

Brakes
Crane
Clark Controller Co.
Electric Controller & Mfg. Co.
Westinghouse Electric & Mfg. Co.
Disc
Westinghouse Electric & Mfg. Co.
Electric
Clark Controller Co.
Electric Controller & Mfg. Co.
Westinghouse Electric & Mfg. Co.

Brushes
Commutator
Baylis Co., The
Calebaugh Self Lubricating Carbon Co.
Carbon Engineering Co.
General Electric Co.
Jeandron, W. J.
Morganite Brush Co., Inc.
National Carbon Co.
Westinghouse Electric & Mfg. Co.
Dynamic and Carbon
Jeandron, W. J.
Morganite Brush Co., Inc.
National Carbon Co.
Westinghouse Electric & Mfg. Co.

Brush Holders
Baylis Company
Flower, D. B.
Westinghouse Electric & Mfg. Co.

Bus Bar Supports
General Electric Co.
Westinghouse Electric & Mfg. Co.

Bushings
Standard Pressed Steel Co.

Cables (See Wire & Cable)

Cable Accessories
Dossert & Co.
Electric Service Supplies Co.
General Electric Co.
Westinghouse Electric & Mfg. Co.

Carbon Brushes
(See Brushes)

Castings, Steel
Falk Corp.

Cement
Commutator
Green Equip. Corp.
Martindale Electric Co.

Chains, Power Transmission
Diamond Chain & Mfg. Co.
Link-Belt Co.
Morse Chain Co.
Philadelphia Gear Works

Circuit Breakers
Condit Electrical Mfg. Co.
Cutter Co.
General Electric Co.
Roller-Smith Co.
Sundh Electric Co.
Westinghouse Electric & Mfg. Co.

Clamps
Electric Service Suplies Co.
General Electric Co.
Westinghouse Electric & Mfg. Co.

Cleats
Square D. Co.

Clutches
Dodge Mfg. Corp.
Weller Mfg. Co.
Friction
Allis-Chalmers Mfg. Co.
Conway Clutch Co.
Link-Belt Co.
Magnetic
Cutler Hammer Mfg. Co.

Coal and Ash Handling Equipment
Dodge Mfg. Corp.
Link-Belt Co.

Coil Winding Machines
Armature Coil Equipment Co.
Electric Service Supplies Co.
Mutual Foundry & Machine Co.

Coil Winding Tools
Mutual Foundry & Machine Co.

Coils
Choke
American Transformer Co.
Electric Service Supplies Co.
General Electric Co.
Porter & Ross, Inc.
Westinghouse Electric & Mfg. Co.

For the addresses of the manufacturers listed here, please refer to their advertisements in this issue. The index to advertisers may be found on page 102.

Coils, Induction
American Transformer Co.

Commutator Cement
Porter & Ross, Inc.

Commutator Slotters
Porter & Ross, Inc.

Commutator Stones
Porter & Ross, Inc.

Compensators
Automatic
Electrical Service Supplies Co.
General Electric Co.
Industrial Controller Co.
Westinghouse Electric & Mfg. Co.
Manual
Allis-Chalmers Mfg. Co.
Fairbanks-Morse Co.
General Eectric Co.
Industrial Controller Co.
Westinghouse Electric & Mfg. Co.

Compressors, Centrifugal
De Laval Steam Turbine Co.

Conductors, Armored
Tubular Woven Fabric Co.

Conduit Fittings
Erie Malleable Iron Co.

Conduits
American Circular Loom Co.
American Wiremold Co.
Tubular Woven Fabric Co.

Connectors and Terminals
Dossert & Co.
General Electric Co.
Ohio Elect. & Cont. Co.
Westinghouse Electric & Mfg. Co.

Control Systems
Monitor Controller Co.

Controllers
Armored for Electric Circuits
Ohio Elec. & Controller Co.
Automatic
Allen-Bradley Co.
Clark Controller Co.
Cutler Hammer Mfg. Co.
Electric Controller & Mfg. Co.
General Electric Co.
Industrial Controller Co.
Monitor Controller Co.
Rowan Controller Co.
Russell Mfg. Co.
Sundh Electric Co.
Westinghouse Electric & Mfg. Co.
Crane
Electric Controller & Mfg. Co.
Monitor Controller Co.
Electric
Industrial Controller Co.
Monitor Controller Co.
Ohio Elect. & Cont. Co.
Finger
Russell Mfg. Co.
Motor
Allen-Bradley Co.
Allis-Chalmers Mfg. Co.
Clark Controller Co.
Condit Electric Mfg. Co.
Electric Controller & Mfg. Co.
General Electric Co.
Industrial Controller Co.
Monitor Controller Co.
Rowan Controller Co.
Square D. Co.
Sundh Electric Co.
Russell Mfg. Co.
Union Electric Co.
Westinghouse Electric & Mfg. Co.
Rheostatic
Monitor Controller Co.
Reversible
Russell Mfg. Co.
Speed
Clark Controller Co.
Monitor Controller Co.

Temperature and Pressure
Taylor Instrument Co.

Conveyors
Link-Belt Co.
Weller Mfg. Co.

Conveyors, Gravity
Standard Conveyor Co.

Cord, Flexible
Hubbell, Inc., Harvey
Okonite Co., The
Rome Wire Co.
Tubular Woven Fabric Co.
U. S. Rubber Co.

Cotton Yarns
Worcester Bleach & Dye Works Co.

Couplings, Flexible
Allis-Chalmers Mfg. Co.
Clark Controller Co.
De Laval Steam Turbine Co.
Dodge Mfg. Corp.
Falk Corp.
Nuttall Co., R. D.
Philadelphia Gear Works
Smith & Serrell

Couplings, Shaft
Standard Pressed Steel Co.

Crane Controllers
Allen-Bradley Co.
Clark Controller Co.

Crane Motors
Sundh Electric Co.
Westinghouse Electric & Mfg. Co.

Cranes, Portable Electric
Elwell-Parker Co.
Shepard Electric Crane & Hoist Co.

Cross Arms
Electric Service Supplies Co.

Cutouts
General Electric Co.
Hubbell, Inc., Harvey
Square D. Co.
Trumbull Elec. & Mfg. Co.
Westinghouse Electric & Mfg. Co.

Cutters
Hole
Koch & Co., Paul W.
Commutator Slotting
Hullhorst Micro Tool Co.

Diagrams, Winding
McGraw-Hill Book Co., Inc.

Drives
Belt
F. L. Smidth & Co.
Silent Chain
Link-Belt Co.

Dust Collecting Systems
Kirk & Blum Mfg. Co.

Dynamos
(See Generators & Motors)

Electric Lighting
Westinghouse Electric & Mfg. Co.

Elevators & Conveyors
Dodge Mfg. Corp.
Link-Belt Co.

Electric Testing Sets
Porter & Ross, Inc.

Enamels, Wire, Wood and Steel
Impervious Varnish Co.
Sterling Varnish Co.
Baking
Benolite Co., Inc.

Engineers, Illuminating
Westinghouse Electric & Mfg. Co.

Engines, Oil
Allis-Chalmers Mfg. Co.
Fairbanks-Morse & Co.

Factory Furniture
Standard Pressed Steel
Westinghouse Electric & Mfg. Co.

Fan Hangers, Electric
Adam Electric Co., Frank

Fan Motors
General Electric Co.
Kirk & Blum Mfg. Co.
Westinghouse Electric & Mfg. Co.

Fans
Exhaust and Ventilating
General Eectric Co.
The Kirk & Blum Mfg. Co.
National Screw & Mfg. Co.
Star Electric Motor Co.
Sturtevant Co., B. F.
Westinghouse Electric & Mfg. Co.

Files, Commutator Slotting
Martindale Electric Co.

Fittings
Pipe
Westinghouse Electric & Mfg. Co.

Financial
Hornblower & Weeks

Fixtures, Lighting
American Fixture Co.
The Holophane Co.
Westinghouse Electric & Mfg. Co.
Industrial
Benjamin Electric Co.

Fire Extinguishers
The Fyr-Fyter Co.

Furnaces, Electric
General Electric Co.
Westinghouse Electric & Mfg. Co.

Fuse Clips
Reinforced Switch & Mfg. Co.
Trumbull Electric Mfg. Co.

Fuse Plugs
Hubbell, Inc., Harvey
Pierce Renewable Fuses, Inc.
Trico Fuse Mfg. Co.
Westinghouse Electric & Mfg. Co.

Fuses
General Electric Co.
Pierce Renewable Fuses, Inc.
Trico Fuse Mfg. Co.
Renewable
Bussmann Mfg. Co.
Pierce Renewable Fuses, Inc.
Trico Fuse Mfg. Co.
Westinghouse Electric & Mfg. Co.
Non-Renewable
Trico Fuse Mfg. Co.

Gears
Cleveland Worm & Gear Co.
Dodge Mfg. Corp.
Falk Corp.
Foote Bros. Gear & Mach. Co.
General Electric Co.
Horsburgh & Scott Co., The
James Mfg. Co., D. O.
Link-Belt Co.
Morse Chain Co.
Nuttall Co., R. D.
Philadelphia Gear Works
Smith, Winfield H.
Westinghouse Electric & Mfg. Co.
Composition
Formica Insulation Co., The
General Electric Co.
Westinghouse Electric & Mfg. Co.
Forged
Philadelphia Gear Works
Helical
De Laval Steam Turbine Co.
Falk Corp.
Foote Bros. Gear & Mach. Co.
James Mfg. Co., Do.
Herringbone
Falk Corp.
Foote Bros. Gear & Mach. Co.
Horsburgh & Scott Co., The
Double Helical
De Laval Steam Turbine Co.
Reducing
Cleveland Worm & Gear Co.
Foote Bros. Gear & Mach. Co.
Winfield H. Smith
Spiral
Foote Bros. Gear & Mach. Co.
Horsburgh & Scott Co., The
Worm
De Laval Steam Turbine Co.
Horsburgh & Scott Co., The

Gear Blanks
Non-Metalic
The Formica Co.

Generating Sets
Allis-Chalmers Mfg. Co.
Crocker-Wheeler Co.
General Electric Co.
Marble-Card Electric Co.
Triumph Electric Co.
Westinghouse Electric & Mfg. Co.

Generators
Allis-Chalmers Mfg. Co.
Bodine Electric Co.
Crocker-Wheeler Co.
Electro Dynamic Co.
General Electric Co.
Lincoln Electric Co.
Marble-Card Elec. Co.
Reliance Electric & Eng. Co.
Star Electric Motor Co.
Triumph Electric Co.
Westinghouse Electric & Mfg. Co.

Glue Pots
Westinghouse Eectric & Mfg. Co.

Grinders
Bodine Electric Co.
Martindale Electric Co.
Tool
Fafnir Bearing Co.
Grinding Appliances
F. L. Smidth & Co.

Grounding Devices
Dossert & Co.

Guards, Machinery
The Kirk & Blum Mfg. Co.

Hangers, Line Shaft
American Pulley Co.
Dodge Mfg. Corp.
Fafnir Bearing Co.
Link-Belt Co.
Rollway Bearing Co., Inc.
Standard Pressed Steel Co.
Thompson Elec. Co.

Hangers, Post
Standard Pressed Steel Co.

Heating and Ventilating
The Kirk & Blum Mfg. Co.

Heating Devices, Industrial
General Electric Co.
Westinghouse Electric & Mfg. Co.
Wiegand Co., E. L.

Hoists, Electric
General Electric Co.
Link-Belt Co.
Shepard Electric Crane & Hoist Co.

Hydraulic Turbines
De Laval Steam Turbine Co.

Indicators, Speed
(See Tachometers).

Industrial Ovens
The Kirk & Blum Mfg. Co.

Instrument Transformers
American Transformer Co.
General Electric Co.
Roller-Smith Co.
Westinghouse Electric & Mfg. Co.

Instruments, Electrical
Graphic
General Electric Co.
Jewell Electrical Instrument Co.
Westinghouse Electric & Mfg. Co.
Indicating
Biddle, James G.
General Electric Co.
Jewell Electrical Instrument Co.
Roller-Smith Co.
Taylor Instrument Co.
Westinghouse Electric & Mfg. Co.
Weston Electrical Instrument Corp.
Integrating
General Electric Co.
Jewell Electrical Instrument Co.
Westinghouse Electric & Mfg. Co.
Scientific and Testing Service
Biddle, James G.
General Electric Co.
Jewell Electrical Instrument Co.
Roller-Smith Co.
Westinghouse Electric & Mfg. Co.
Weston Electrical Instrument Co.

Insulating Material
Comp. Cloth and Paper
General Electric Co.
Mica Insulator Co.
Westinghouse Electric & Mfg. Co.
Compounds, Paints and Varnishes
Benolite Co., Inc.
Dolph Co., John C.
General Electric Co.
Impervious Varnish Co.
Irvington Varnish & Insulator Co.
Martindale Electric Co.
Mica Insulator Co.
Okonite Co.
Sterling Varnish Co.
Westinghouse Electric & Mfg. Co.
Fibre, Tape and Webbing
Irvington Varnish & Insulator Co.

Insulators
Electric Service Supplies Co.
General Electric Co.
Irvington Varnish & Insulator Co.
Square D. Co.
Westinghouse Electric & Mfg. Co.
Fibre
General Electric Co.
Tape and Webbing
General Electric Co.
Mica Insulator Co.
Okonite Co., The
U. S. Rubber Co.
Westinghouse Electric & Mfg. Co.

Investments
Hornblower & Weeks

Joints
Cable Splicing
Dossert & Co.

Lamp Guards
Electric Service Supplies Co.
Hubbell, Inc., Harvey
Westinghouse Electric & Mfg. Co.

Lamp Locks
Ren Mfg. Co.

Lamps
Arc
General Electric Co.
Westinghouse Electric & Mfg. Co.
Incandescent
General Electric Co.
The Holophane Co.
Nitrogen
Westinghouse Electric & Mfg. Co.

Lifting Magnets
Electric Controller & Mfg. Co.
Ohio Elect. & Cont. Co.

Lighting, Industrial
American Fixture Co.
General Electric Co.
The Holophane Co.
National Screw & Mfg. Co.
Westinghouse Electric & Mfg. Co.

Lightning Arresters
Electric Service Supplies Co.
General Electric Co.
Westinghouse Electric & Mfg. Co.

For the addresses of the manufacturers listed here, please refer to their advertisements in this issue. The index to advertisers may be found on page 102.

Line Materials
Electric Service Supplies Co.

Locks, Lamp
Ren Mfg. Co.

Lubricants
Standard Oil Co. (Ind.)

Machine Racks
Foote Bros. Gear & Mach. Co.

Magnetic Separators
Electric Controller & Mfg. Co.

Magnets
Cutler-Hammer Mfg. Co.

Magnets, Lift
Electric Controller & Mfg. Co.
Ohio Elect. & Cont. Co.

Material Handing Equipment
Dodge Mfg. Corp.
Link-Belt Co.
Shepard Electric Crane & Hoist Co.
Standard Pressed Steel Co.
Weller Mfg. Co.

Metal Stampings
American Pulley Co.
Dodge Mfg. Corp.
The Kirk & Blum Mfg. Co.
Standard Pressed Steel Co.

Meters
General Electric Co.
Roller-Smith Co.
Westinghouse Electric & Mfg. Co.

Meter Testers
General Electric Co.
Westinghouse Electric & Mfg. Co.

Mica
Raw and Products
Mica Insulator Co.

Mica Under Cutting Machines
Hullhorst Micro Tool Co.

Molding, Metal
Appleton Electric Co.

Motors
Allis-Chalmers Mfg. Co.
Baldor Electric Co.
Century Electric Co.
Crocker-Wheeler Co.
Electro Dynamic Co.
Fairbanks-Morse & Co.
General Electric Co.
Howell Electric Motor Co.
Imperial Electric Co.
Lincoln Electric Co.
Marble-Card Electric Co.
National Screw & Mfg. Co.
Ohio Elect. & Cont. Co.
Reliance Electric & Eng. Co.
Star Electric Motor Co.
Sturtevant Co., B. F.
Triumph Electric Co.
Westinghouse Electric & Mfg. Co.
Electric
Ohio Elec. & Controller Co.
Fractional H. P.
Bodine Electric Co.
Ohio Elect. & Cont. Co.

Motor Generators
Allis-Chalmers Mfg. Co.
Bodine Electric Co.
Burke Electric Co.
Crocker-Wheeler Co.
Ohio Elect. & Cont. Co.
Reliance Electric & Eng. Co.
Triumph Electric Co.
Westinghouse Electric & Mfg. Co.

Motor Generator Sets
Bodine Electric Co.

Oil Cups
Gits Brothers Mfg. Co.

Oil Engines
Falk Corp.

Oil Gages
Gits Brothers Mfg. Co.

Oil Purifiers, Centrifugal
De Laval Steam Turbine Co.

Outlets
American Wiremold Co.

Ovens, Electric
General Electric Co.
Westinghouse Electric & Mfg. Co.

Paint Spray Brushes
Simons Paint Spray Brush Co.

Panel Boards
Adam Electric Co., Frank
Benjamin Electric Co.
General Electric Co.
Trumbull Vanderpoel Electric Co.
Westinghouse Eectric & Mfg. Co.

Panels, Switchboard
General Electric Co.
Westinghouse Electric & Mfg. Co.

Pinions
Foote Bros. Gear & Mach. Co.

Plugs
Benjamin Electric Co.
General Electric Co.
Hubbell, Inc., Harvey
Westinghouse Electric & Mfg. Co.
Attachments
Hubbell, Inc., Harvey

Post Boxes
Standard Pressed Steel Co.

Potentiometers
Biddle, James G.
General Electric Co.
Westinghouse Electric & Mfg. Co.

Power Transmission Appliances
Allis-Chalmers Mfg. Co.
American Pulley Co.
Diamond Chain & Mfg. Co.
Dodge Mfg. Corp.
Fafnir Bearing Co.
Foote Bros. Gear & Mach. Co.
James Mfg. Co., D. O.
Link-Belt Co.
Nuttall Co., R. D.
Reeves Pulley Co.
Rollway Bearing Co., Inc.
F. L. Smidth & Co.
Standard Pressed Steel Co.

Pressed Steel Parts
The Kirk & Blum Mfg. Co.
Standard Pressed Steel Co.

Projectors, Floodlighting
Electric Service Supplies Co.
Westinghouse Electric & Mfg. Co.

Protective Coatings
Benolite Co., Inc.

Protective Devices
Condit Elec. Mfg. Co.
General Electric Co.
Industrial Controller Co.
Westinghouse Electric & Mfg. Co.

Pulleys
American Pulley Co.
Dodge Mfg. Corp.
Fafnir Bearing Co.
Link-Belt Co.
Reeves Pulley Co.
Rockwood Mfg. Co.
Smith, Winfield H.
Paper
Rockwood Mfg. Co.

Pull Sockets
Hubbell, Inc., Harvey

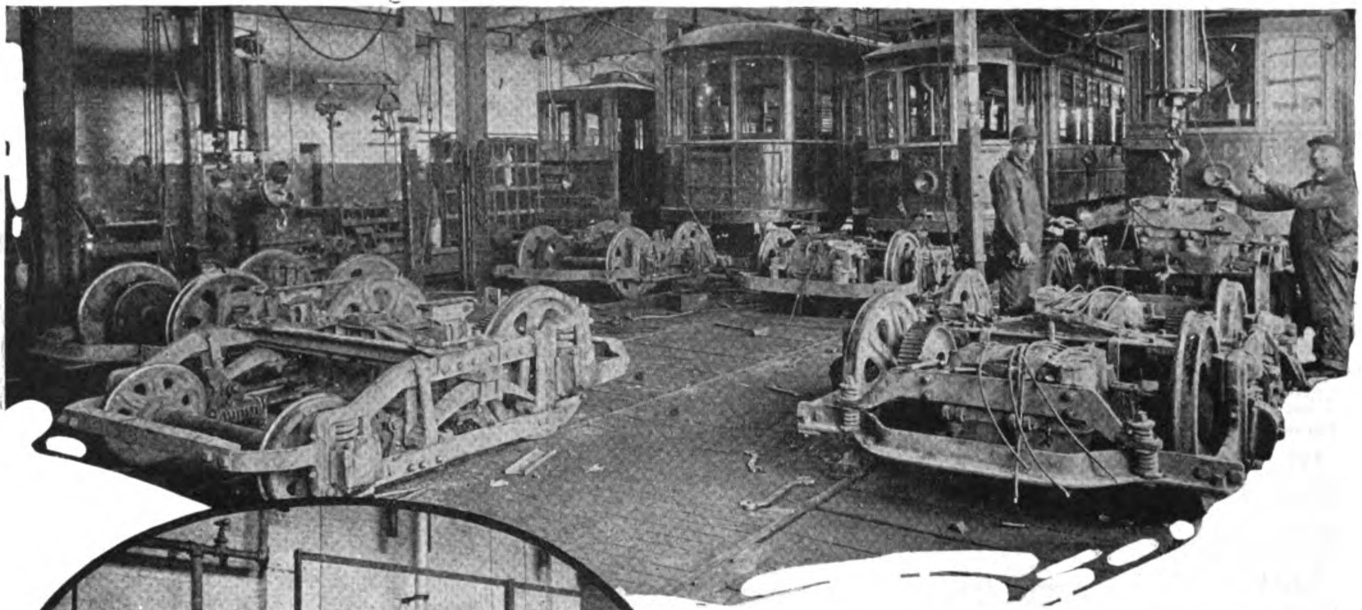
Pumps
Boiler Feed
De Laval Steam Turbine Co.
Centrifugal
Allis-Chalmers Mfg. Co.
De Laval Steam Turbine Co.
Fire
De Laval Steam Turbine Co.
General Service
De Laval Steam Turbine Co.
Reciprocating
Allis-Chalmers Mfg. Co.
Stock
De Laval Steam Turbine Co.

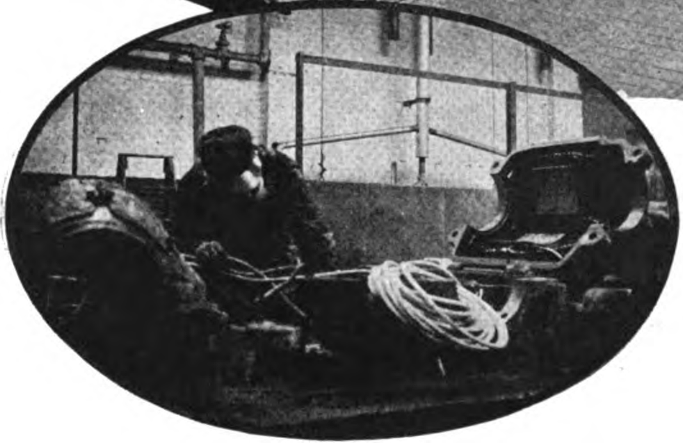
Pyrometers
Taylor Instrument Co.

Recorders, Temperature and Pressure
Taylor Instrument Co.

Rectifiers
General Electric Co.
Westinghouse Electric & Mfg. Co.

Reflectors
Benjamin Electric Co.
The Holophane Co.
Hubbell, Inc., Harvey
National Screw & Mfg. Co.
Thompson Electric Co.
Westinghouse Electric & Mfg. Co





TIREX Motor Lead Cable being installed on railway motors at the Washington Railway & Electric Co., Washington, D. C.

Tirex

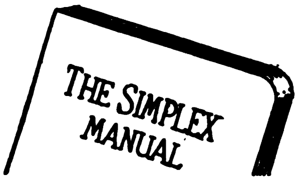
—the cable to specify for motor leads

Electric railways are regularly using TIREX Motor Lead Cable because they find it eliminates the costly cable lead troubles as one of their problems.

Electric railway engineers were quick to learn the admirable qualities of TIREX Cables for motor leads. *And any cable that will stand the rugged service required in electric railway operation, is a good cable to specify for your own motor leads.*

TIREX is as flexible as a rubber hose. Note the multiplicity of fine wires which make up the copper conductor. The conductors are insulated with a high grade rubber compound and the cable is protected by TIREX "rubber armor" which is almost wear-proof and satisfactory for all kinds of rough work.

Notice, too, the special feature which distinguishes TIREX Motor Lead Cables from the regular line of TIREX Cables, the paper tape between the copper and rubber. "Skinning" cable for connections is easy because when the insulation is removed the conductor is left clean, ready for connecting to motor terminals.



Get all the facts on this splendid indestructible cable.

Use the coupon.

SIMPLEX WIRE & CABLE Co

MANUFACTURERS

201 DEVONSHIRE ST., BOSTON

New York Chicago San Francisco Cleveland Jacksonville

Simplex Wire & Cable Co.,
201 Devonshire St., Boston, Mass.

Gentlemen:—

Please send me the Simplex Manual. ☐

Please send quotation on Tirex Motor Lead Cables. ☐

Size.................... No. of Conductors.............

Voltage..................... Feet....................

Name ....

Position ....

Company ....

Address ....

City ....

State ....

Regulators
Controller
Monitor Controller Co.
Induction Voltage
General Electric Co.
Westinghouse Electric & Mfg. Co.
Pressure
Electric Controller & Mfg. Co.
Speed
Industrial Controller Co.
Temperature and Pressure
Electric Controller & Mfg. Co.
Taylor Instrument Co.
Relays, Overload
Allen-Bradley Co.
Repair Data
Cutler Hammer Mach. Co.
McGraw-Hill Book Co., Inc.
Resistance Units
General Electric Co.
Monitor Controller Co.
Westinghouse Electric & Mfg. Co.
Rheostats
Allen-Bradley Co.
Biddle, J. G.
Cutler Hammer Mfg. Co.
Electric Controller & Mfg. Co.
General Electric Co.
Industrial Controller Co.
Monitor Controller Co.
Westinghouse Electric & Mfg. Co.
Rivets
Hubbell, Inc., Harvey
National Screw & Mfg. Co.
Roller Chains
Link-Belt Co.
Rosettes
Hubbell, Inc., Harvey
Schools
Ft. Wayne Correspondence School
Screw Machines, Automatic
Standard Pressed Steel Co.
Screws
Hollow, Cap and Set
National Screw & Mfg. Co.
Standard Pressed Steel Co.
Machine
Hubbell, Inc., Harvey
Searchlights
General Electric Co.
Westinghouse Electric & Mfg. Co.
Second-Hand Apparatus
(See Searchlight Section)
Gregory Electric Co.
Shapes, Pressed Steel
American Pulley Co.
The Kirk & Blum Mfg. Co.
Silent Chain Drives
Link-Belt Co.
Morse Chain Co.
Slot Cleaning Tools, Commutator
Martindale Electric Co.
Slotters, Commutator
Green Equipment Corp.
Hullhorst Micro Tool Co.
Martindale Electric Co.
Sockets and Receptacles
Benjamin Electric Co.
General Electric Co.
Hubbell, Inc., Harvey
Westinghouse Electric & Mfg. Co.
Solder
Allen Co., L. B.
Westinghouse Electric & Mfg. Co.

Soldering Compounds
Allen Co., L. B.
Space Heaters
Cutler-Hammer Mfg. Co.
Westinghouse Electric & Mfg. Co.
Wiegand Co., Edwin L.
Speed Reducers
Falk Corp.
Foote Bros. Gear & Mach. Co.
Horsburgh & Scott Co., The
James Mfg. Co., D. O.
Philadelphia Gear Works
Smith, Winfield, H.
Speed Reducers (Chain)
Link-Belt Co.
Morse Chain Co.
Speed Transformers
De Laval Steam Turbine Co.
Sprockets
Diamond Chain & Mfg. Co.
Dodge Mfg. Corp.
James Mfg. Co., D. O.
Link-Belt Co.
Morse Chain Co.
Philadelphia Gear Works
Stampings & Drawings
The Kirk & Blum Mfg. Co.
Starters, Motor
(See Controllers)
Steam Turbines
De Laval Steam Turbine Co.
Stones, Commutator
Green Equipment Corp.
Martindale Electric Co.
Strip Heaters
Westinghouse Electric & Mfg. Co.
Wiegand Co., Edwin L.
Substations, Outdoor
General Electric Co.
The Holophane Co.
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Supplies, Electrical
Flower, D. B.
Green Equipment Corp.
General Electric Co.
Hubbell, Inc., Harvey
Lincoln Electric Co.
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Electric Service Supplies Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.
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Adam Electric Co., Frank
General Electric Co.
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Westinghouse Elec. & Mfg. Co.
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Adam Electric Co., Frank
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General Electric Co.
Trumbull-Vanderpoel Electric Co.
Westinghouse Elec. & Mfg. Co.
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Air Brake and Pole Top
Condit Electrical Mfg. Co.
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Union Electric Mfg. Co.

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Allen-Bradley Co.
Electric Controller & Mfg. Co.
Industrial Controller Co.
Monitor Controller Co.
Sundh Electric Co.
Union Elec. & Mfg. Co.
Westinghouse Elec. & Mfg. Co.
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Electric Controller & Mfg. Co.
General Electric Co.
Industrial Controller Co.
Porter & Ross, Inc.
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Float
Electric Controller & Mfg. Co.
General Electric Co.
Industrial Controller Co.
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Adam Electric Co., Frank
Condit Electrical Mfg. Co.
Reinforced Switch & Mfg. Co.
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Adam Electric Co., Frank
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Cutter Co.
General Electric Co.
Reinforced Switch & Mfg. Co.
Trumbull Electric Mfg. Co.
Trumbull-Vanderpoel Electric Co.
Westinghouse Elec. & Mfg. Co.
Magnetic
Allen-Bradley Co.
Electric Controller & Mfg. Co.
Industrial Controller Co.
Monitor Controller Co.
Rowan Controller Co.
Sundh Electric Co.
Westinghouse Elec & Mfg. Co.
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Allen-Bradley Co.
Condit Electrical Mfg. Co.
Electric Controller & Mfg. Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.
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Hubbell, Inc., Harvey
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Allen-Bradley Co.
Electric Controller & Mfg. Co.
General Electric Co.
Industrial Controller Co.
Monitor Controller Co.
Rowan Controller Co.
Sundh Electric Co.
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Square D Co.
Trumbull Electric Mfg. Co.
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General Electric Co.
Monitor Controller Co.
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Snap
Hubbell, Inc., Harvey
Surface and Flush
General Electric Co.
Trumbull Electrical Mfg. Co.
Westinghouse Elec. & Mfg. Co.
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General Electric Co.
Westinghouse Elec. & Mfg. Co.
Synchronous Motor Starters
Allen-Bradley Co.
Electric Controller & Mfg. Co.
Synchroscopes
General Electric Co.
Roller-Smith Co.
Westinghouse Elec. & Mfg. Co.
Weston Electrical Ins't. Corp.
Tachometers
Biddle, James G.
Westinghouse Elec. & Mfg. Co.
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The Kirk & Blum Mfg. Co.
Tape
Friction
Porter & Ross, Inc.
Rubber
Porter & Ross, Inc.
Tape & Webbing
Irvington Varnish & Insulator Co.
Mica Insulator Co.
Okonite Co., The
U. S. Rubber Co.
Testing Apparatus
American Transformer Co.
Biddle, James G.
Century Electrical Co.
General Electric Co.
Roller-Smith Co.
Square D Co.
Westinghouse Elec. & Mfg. Co.
Weston Electrical Ins't. Corp.
Thermometers, Indicating & Recording
Taylor Instrument Co.
Tools
Klein & Sons, Mathias
Koch & Co., Paul W.
Electric
Porter & Ross, Inc.
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American Transformer Co.
General Electric Co.
Kuhlman Electric Co.
Porter & Ross, Inc.
Westinghouse Elec. & Mfg. Co.
Transmission Machinery
Standard Pressed Steel Co.
Transmissions
James Mfg. Co., D. O.
Variable Speed
Reeves Pulley Co.
Ball Bearing
Reeves Pulley Co.

Tree Wire
Okonite Co.
Trucks & Tractors
Industrial Electric
Elwell-Parker Electric Co.
Tubing, Light Wall Steel
American Circular Loom Co.
Undercutting Machines, Mica
Hullhorst Micro Tool Co.
Varnish, Insulating
Benolite Co., Inc.
Sterling Varnish Co.
Varnishes, Cable
Impervious Varnish Co.
Mica Insulator Co.
Sterling Varnish Co.
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Kirk & Blum Mfg. Co.
Welders
Arc
Burke Electric Co.
General Electric Co.
Lincoln Electric Co.
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Electric
Lincoln Electric Co.
Welding Machines
General Electric Co.
Westinghouse Elec. & Mfg. Co.
Wires and Cables
Asbestos Covered
American Steel & Wire Co.
Rockbestos Co.
Bare Copper
American Insulated Wire & Cable Co.
American Steel & Wire Co.
Rome Wire Co.
Enameled
Maring Wire Co.
Insulated
American Steel & Wire Co.
Okonite Co., The
Tubular Woven Fabric Co.
York Insulated Wire Co.
Magnet
American Steel & Wire Co.
Maring Wire Co.
Porter & Ross, Inc.
Rome Wire Co.
Magnet, Enameled
Rome Wire Co.
Reinforced, Flexible
American Steel & Wire Co.
Rome Wire Co.
Simplex Wire & Cable Co.
Tubular Woven Fabric Co.
Resistance
General Electric Co.
Westinghouse Elec. & Mfg. Co.
Rope
American Steel & Wire Co.
Rubber Covered and Weatherproof
American Insulated Wire & Cable Co.
American Steel & Wire Co.
Okonite Co., The
Rome Wire Co.
Simplex Wire & Cable Co.
Tubular Woven Fabric Co.
U. S. Rubber Co.
Underground (Cable)
American Steel & Wire Co.
Rome Wire Co.
Welding
Lincoln Electric Co.
Varnished Cambric
Okonite Co., The

DURACORD

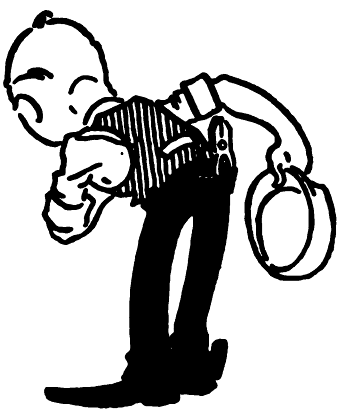
REG. U.S. PAT. OFF.

Heavy Duty Portable Cord

You can treat it rough!

Take a tip from the big boys—they pick Duracord 'cause it won't quit on the job, it's tough, stands abuse, and lasts longer. Put Duracord on yer toughest job—and see for yerself.

Dura Bill



Your Electrical Jobber stocks DURACORD
It's one of the DURABILT PRODUCTS

Made by the Tubular Woven Fabric Company,
Pawtucket, R. I.

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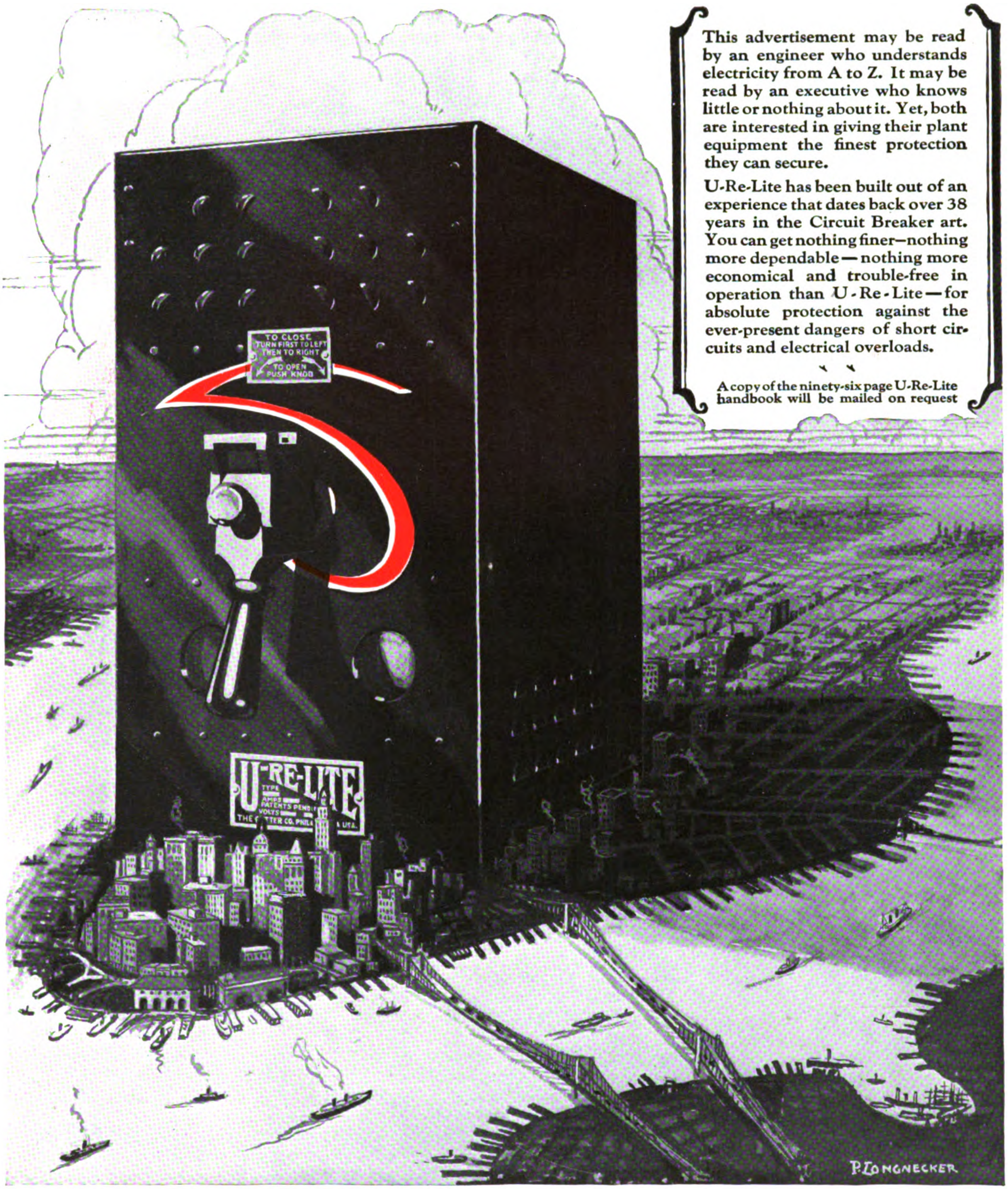

This advertisement may be read by an engineer who understands electricity from A to Z. It may be read by an executive who knows little or nothing about it. Yet, both are interested in giving their plant equipment the finest protection they can secure.

U-Re-Lite has been built out of an experience that dates back over 38 years in the Circuit Breaker art. You can get nothing finer—nothing more dependable—nothing more economical and trouble-free in operation than U-Re-Lite—for absolute protection against the ever-present dangers of short circuits and electrical overloads.

A copy of the ninety-six page U-Re-Lite handbook will be mailed on request

CUTTER

U-RE-LITE · I-T-E CIRCUIT BREAKERS

THE CUTTER COMPANY — *Established in 1888* — PHILADELPHIA, PENNSYLVANIA

As they Say at John B. Stetson Company

Class 7107 D. C. Starter—Time Limit Acceleration

James Black, *Electrical Engineer, John B. Stetson Company, Philadelphia,* says: "We are using about 300 I-C Across-the-Line Automatic Starters, classes 7110, 7120 and 7107, on D. C. motors ranging from ½ to 50 H. P. Practically 70% of our drive motors are so equipped, and we are buying no more hand starters.

"In several instances we have more than one push button to control motors driving line shafts. In our machine shop, for instance, in a space of about 100 feet, any one of 3 push buttons will stop or start the main motor. This saves time and power and is invaluable in emergencies.

"With the old type open switches, operators were sometimes burned; and in damp places, such as our sizing department, an open switch or a hand starter was actually dangerous. I-C starters are always safe.

"These automatic starters are easy to install and cost little to maintain. Many of our I-C starters are equipped with overload relays, which protect motors and machinery, and save time lost in locating and replacing blown fuses.

"Service from Industrial Controller Company has been very satisfactory."

Industrial Controller Co.
MILWAUKEE, WIS. U.S.A.